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COPPER, CADMIUM, ZINC, NICKEL, ETC.

COPPER, cadmium, zinc, nickel, cobalt, manganese, and iron may occur in certain ores and in a number of industrial alloys. Their successive separation in analysis presents great practical differences by reason of the analogous properties of their salts.

The methods of separation about to be explained are principally founded upon the use of sodium or ammonium hyposulphite, and on that of sulphureted hydrogen in solutions successively acidified by sulphuric or hydrochloric acid, by oxalic acid, and, lastly, by acetic acid.

The precipitation of copper by sodium hyposulphite in a boiling sulphuric solution was first recommended by Flajolot as a means of separating it from zinc and nickel. Much more recently Vortmann found that the same reagent effects the separation of copper and cadmium with great exactitude.

The author has satisfied himself of this fact, under different conditions which appeared preferable and making use of ammonium hyposulphite, which in comparison with the sodium salt has the advantage of not introducing a fixed alkali.

The solution containing copper, cadmium, and other metals diluted to 200 or 300 c. c. is acidified with 10 to 15 c. c. hydrochloric acid, heated to boiling and mixed with hyposulphite, added in successive portions until the precipitate, instead of becoming at once a deep brown from the formation of copper sulphide, remains for some time white and milky, from the liberation of sulphur. When the liquid is cleared by boiling, the precipitate is collected on a filter. It contains all the copper as Cu_2S. It is dried, the filter is burnt, mixed with powdered sulphur, and ignited in a small crucible traversed by a current of dry hydrogen (H. Rose's apparatus). The sulphide is weighed, containing 79·87 of copper. The cadmium may be precipitated by sulphureted hydrogen or ammonium hydrosulphate.

The separation of cadmium and zinc is effected by an analogous operation, care being taken that the solution contains no other free acid save oxalic acid, and that the precipitated sulphides are not mixed with oxalates.

It must be observed, to this end, that the zinc is precipitated as simple oxalate, scarcely soluble in ammonium chloride, while the cadmium forms in presence of ammonia a double oxalate, easily soluble in the same reagent. If we add beforehand 10 parts of ammonium chloride to 1 part of metal, we may completely prevent the precipitation of cadmium by oxalic acid or ammonium oxalate. The operation may be thus conducted, whatever are the relative proportions of zinc and cadmium.

The solution, supposed to be acid and but little diluted, is exactly neutralized with ammonia. An excess of sal ammoniac is then added, and about 2 grms. oxalic acid in solution, and the whole is boiled for some minutes. If the zinc is in notable quantity, and forms a crystalline deposit of oxalate, it is separated by decantation and washed with a hot solution of ammonium chloride. If it is in very small quantity there may be no deposit to separate. The solution, containing all the cadmium and a little zinc, diluted to 200 or 250 c. c. and raised to a boil, ought not to give any further precipitate. There is then added at once or in several portions ammonium hyposulphite, acidifying afresh, if needful, with oxalic acid, and it is kept at a boil as long as the orange precipitate of cadmium sulphide appears to increase.

Each fresh addition of the reagent gives rise at first to a milky white precipitate of sulphur, which gradually turns orange. We ascertain that the precipitation is complete by decanting a portion of the liquid through a filter, adding a little more hyposulphite and oxalic acid, and boiling again. It ought to give merely a white turbidity, and finally a light yellow deposit of sulphur.

The zinc is found entirely in the oxalic solution and in the first crystalline precipitate. The latter is calcined separately, and converted into zinc oxide. The zinc in the solution is precipitated by a current of sulphureted hydrogen. The whiteness of the precipitate shows that the liquid did not contain a trace of cadmium. It is filtered, dried, the filter burnt, and the whole ignited in a small Rose's crucible traversed by a current of dry hydrogen sulphide. The zinc sulphide, the sulphate which may have been formed during the combustion of the filter, and the oxide derived from the decomposition of the oxalate, are all brought to the state of sulphide containing 67·13 per cent. of zinc.—*A. Carnot, Comptes Rendus* (cii., p. 621); *Chem. News.*

FIG. 1.

FIG. 6.

FIG. 3.—AUTOMATIC WEIGHING MACHINE.

AUTOMATIC WEIGHING MACHINE.

WE recently had an opportunity of inspecting at Messrs. Avery's several new automatic weighing machines, which appear to us to admit of an almost endless application. At present they have been chiefly applied to the weighing into tins and packages a known and regular weight of some food product or to the exact filling of given weights of seidlitz and other powders into packets.

The present method of conducting much of the food and drug trade has called for some system of weighing at once accurate, rapid, and reliable, and this machine fully merits these distinctions, for it may be adjusted to give any weight in any number of repetitions. Such a property makes it valuable to the large supplier of packed foods, who, while always giving full weight, is wishful not to give too much draw. The time lost in hand weighing by economizing the amount of draw is perhaps of greater value than the material thus saved. With the automatic machine the amount of extra material allowed being once fixed upon, every package afterward weighed off is then exact.

As made by W. & T. Avery, Birmingham, in the form shown in Fig. 1, the case to be filled is placed upon a plate which forms one end of the scale, and the material falls from a hopper above as the weight desired is approached, the scale pan commences to fall, and this sets in motion the upright rod, which carries the shutter-plate or gate, which closes the hopper spout.

The case being removed a new one is substituted, and the hopper opened by raising the "scale pan," and the above cycle of operations repeats itself.

When once adjusted to a given weight, which is effected by moving a balance weight by a screw, the same weight will ever after run out at each operation from the hopper.

A slight modification is made in the form of the machine, Fig. 2. Here the material weighed falls into one of the three hoppers shown, and which revolve around a common center. Into each receptacle the quantity desired is weighed off in turn from the hopper above, and as the frame is rotated the under opening of this hopper (and while this hopper is emptying another is filling) comes over a hole in the base plate, and the contents discharge into the bag or box. The advantage of this machine is that it gives the net weight of the material. In the third machine we illustrate there are several machines combined on one table, which revolves round a central pillar.

Cases of cardboard or tin boxes travel to the machine upon an endless carrier belt. Each scale takes off a box as it comes to the delivery point of the belt, and in revolving with the whole frame the box is filled up from the hopper and taken off by another carrier belt after revolving through about five-sixths of the circle. The belt which conveys the filled package from the machine is fitted with a tapping arrangement in order to pack the material closely.

Our Fig. 3 gives a general idea of this machine, which may be of any size to accommodate a large number of separate weighing scales. Hence its rapidity of action may be increased to any speed.

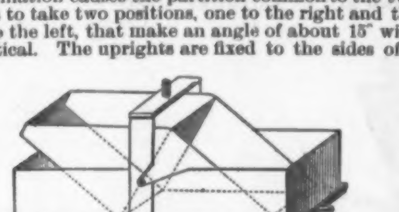
Considerable ingenuity has had to be expended in rendering these machines available for some substances. Thus, for example, the article tea is most difficult to manipulate, owing to some leaves being large while others are powdered, but this has now been overcome by suitable hopper agitators.

Flours, powders, and sugars flow with difficulty and require special screw agitators. The use of such machines is of course not limited to food products. Anything of a granular or divided nature may be dealt with.

The number of packages which can be weighed in a hand machine is from 500 to 1,500 per hour, and in a power machine from 1,000 to 3,000 or 4,000 per hour, or even more if required.—*Iron.*

AUTOMATIC APPARATUS FOR WASHING NEGATIVES.

THE annexed engraving, from *La Nature*, represents an automatic apparatus devised by Mr. Gorceix for washing photographic negatives. It consists of two triangular prismatic troughs placed back to back, and oscillating on a rod passing through them a little above their center of gravity and supported by two uprights. The oscillation causes the partition common to the two troughs to take two positions, one to the right and the other to the left, that make an angle of about 15° with the vertical. The uprights are fixed to the sides of a



APPARATUS FOR WASHING NEGATIVES.

box provided with a waste tube, and are connected at their upper part by a cross-piece, that carries a tube through which water continuously enters the troughs. The water, on entering the compartment below, raises the center of gravity laterally, and when the latter gets above the axis, the troughs tilt. A part of the water is thus emptied into the box, while the rest, being held back by a narrow rim, covers the plate and enters the gelatine.

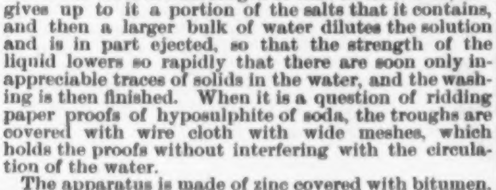
As a consequence of the rocking motion, the other trough is brought under the stream of water and becomes full in its turn, and the two troughs then tilt in the opposite direction. These motions continue as long as the water flows, and their frequency depends upon the discharge, which may be regulated at will by means of a cock.

It will be seen that when once operations have begun, the washing proceeds very regularly. The negative soaks for a certain length of time in the water, and gives up to it a portion of the salts that it contains, and then a larger bulk of water dilutes the solution and is in part ejected, so that the strength of the liquid lowers so rapidly that there are soon only inappreciable traces of solids in the water, and the washing is then finished. When it is a question of ridding paper proofs of hyposulphite of soda, the troughs are covered with wire cloth with wide meshes, which holds the proofs without interfering with the circulation of the water.

The apparatus is made of zinc covered with bitumen, which is afterward exposed to the sun.

NEW EXTRACTOR FOR DYE-WOODS.

ONE of the most recently devised apparatus for extracting the principles contained in dye-woods or other substances is shown in the accompanying engraving. It is an Austrian invention, and consists of a boiler, A, provided with a man-hole, *z*, and of a certain number of extractors, B, provided with safety-valves, L, and connected with the boiler. In the upper part, *o*, of the extractors are placed coolers formed of two perforated disks, *b*, whose superposed apertures are connected by cones, *c*. The material to be exhausted is placed between the perforated partitions, S, and the extractor is then closed with its cap, O, and the receptacle, T, is filled with water through the tube, *d*, which carries a cock, *h*. The extracting medium (water, alcohol, or other fluid), which has been placed in the boiler, is heated by steam introduced beneath the false bottom. The vapors rise in the pipe, M, pass into the part, *m*, of the extractor, are condensed by the cones, and fall through the apertures in the disk, S,



NEW EXTRACTOR FOR DYE-WOODS.

upon the substance to be exhausted. In the interior of the extractor there is another cooler which tends to still further condense the vapors. The product of this condensation collects beneath the lower perforated disk, S, and then returns to the boiler through the pipe, *n*. The extracted product remains in the boiler, while the solvent is volatilized anew, and thus passes several times over the substance. This operation is continued until a test shows that the solvent is no longer acting.

It is well to employ several extractors, one of which is empty, while the second is full, and the others are in action. The operation is continued, and does not cease until the boiler is to be emptied. To effect this, the cock, *v*, of the pipe, M, is closed, and the cock, *p*, is opened and the steam allowed to escape through the pipe, *g*. The extract is removed through the cock, *q*.

When steam is used for the extracting, it is introduced into the cooler and cap in the same manner as already described for other vapors.—*Bull. du Mus. de l'Industrie.*

NEW STYLE OF OX-SHOES.

UP to the present time, oxen have always been shod by means of two disks fixed under the toes by nails. This well preserves the horn of the hoof against wear, but the animal does not walk with confidence with such shoes, especially on ice. Mr. Brasseur, a horseshoe manufacturer at Berry-au-Bac, has devised a new style of shoe, which is shown in the accompanying engravings from the *Chronique Industrielle.* Fig. 1

FIG. 1.

shows the foot of an ox shod with this new device, and Fig. 2 represents the under surface of the latter.

The shoe consists of two iron plates, A and B, which are applied to the bottom of the hoof, and which are provided with a projection that nearly follows the contours of the external edge. The projection, D, on the iron for the inner toe is continuous, so as not to hurt the animal while walking, and the one on the iron for the outer toe is, in the example shown, divided into teeth, and is designed for use in winter when the ground is slippery. In ordinary weather two irons are provided with unbroken projections. Two tongues, E

FIG. 2.

and F, soldered separately to the two plates, A and B, pass between the toes, and are bent back upon the latter in such a way as to hold the shoe in place and act as a substitute for nails, which cannot be driven into the center of the hoof, owing to the thinness of the horn in that place.

APPARATUS FOR DISTRIBUTING LIQUID CARBONIC ACID BY MEASURE.

LIQUID carbonic acid, which has for the last few years been manufactured in large quantities, is, as well known, sent out in hermetically closed iron flasks.

Mr. Luhmann, of Rogasen, in order to facilitate the use of carbonic acid in this form, has invented an apparatus that permits of passing it, in accurately measured quantities, into a closed receptacle, either in order to fill the latter with gaseous carbonic acid or to saturate a liquid with the gas.

The flask, A, of liquid carbonic acid is placed in the inverted position shown in Fig. 1, and is put in communication with the proportioning device, B, which performs the role of a two-way cock. This apparatus (Fig. 2), which is of copper, is in shape like a laboratory retort, and its neck constitutes the key of a cock. When this device is full, it is only necessary to revolve it 180° to put the part, P, in communication with the reservoir, C. This latter operates precisely like the

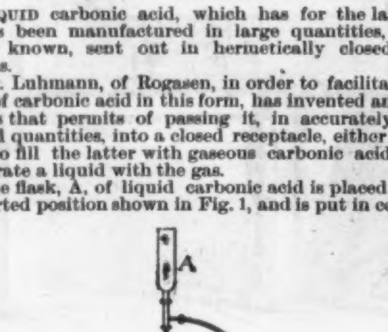


FIG. 1.

saturator employed in the manufacture of mineral waters.

Knowing the ratio between the capacity of the measuring apparatus and that of the saturator, the volume of the liquid being deducted, and knowing how many

FIG. 2.

cubic inches of carbonic acid gas are given by one pint of the liquid acid, we know how many turns of the cock it requires to saturate the liquid in C at a pressure determined in advance.

This apparatus may be used with advantage as a substitute for the pressure pumps used for dispensing beer.—*Chronique Industrielle.*

BUTTER AND OLEOMARGARINE.

THE following good common sense is from the supplement to the fourth annual report of the State Board of Health of Massachusetts:

Butter.—In this country, until recently, butter has been free from adulteration, though occasionally a sample has been met with containing starch.

The most common impurities met with in genuine butter are excess of water and salt. Good butter when freshly cut should not show any cavities containing discolored water, and should not, on analysis, give over nine to twelve per cent. of water. Fresh butter should not contain more than three per cent. of salt. Salt butter may contain as high as one ounce to the pound; any amount above this should be considered an adulteration. Butter poorly prepared is apt to contain a little curd and some buttermilk. A butter that is intended for storage for winter use should be free from both these substances, since they serve to render it rancid much sooner than it would be in their absence. They may be detected by examination of the butter with the microscope, or by melting the butter in a test-tube at a gentle heat, and allowing it to stand for some time in a place heated to about 110° Fahrenheit, when the buttermilk, water, and curd will settle and form a layer under the fat.

The *amount* of water may be determined by drying two or three grains of the butter over the water-bath in a flat platinum dish, for two or three hours.

The amount of curd may be ascertained by dissolving the dry fat in benzine, and weighing the residue on a dried filter. This is ignited, and the amount of ash determined and subtracted from the total weight of the residue on the filter; this gives the weight of the curd. The ash may be all reckoned as salt. The analysis of some of the brands of butter sold in the Boston market gave the following results:

	Fat.	Water.	Curd.	Ash.
Alderney................	87·78	9·44	2·02	0·76
"	87·89	9·94	2·68	1·49
"	86·95	9·52	1·65	1·88
Common bakers'.......	87·14	9·88	1·90	1·08

If the amount of matter insoluble in benzine is large, it should be examined by the microscope, and by testing with iodine, for starch. It is said that soapstone or steatite in the form of a fine powder has been used for adulterating butter. If this is used to any extent, it may be readily detected by dissolving the ash in water, when it would remain insoluble.

The presence of other fats than butter fat is sometimes suspected, but no very satisfactory tests have yet been found for the same. Most of the tests given in the books proceed on the assumption that some special fat is used, and directions are given to test butter by its melting-point flavor and odor; on heating, all of these tests may in certain cases mislead.

Oleomargarine.—The closest imitation of butter yet made is undoubtedly the oleomargarine of M. Mégé. This, when properly made, agrees with butter in its melting-point. It is a little deficient in flavor, but not more so than many samples of butter. If carelessly made it may contain traces of membrane, which are represented by the curd found in common butter. It may also show crystals of the stearates, but old butter frequently does the same; and butter that has been melted always shows crystals. The most satisfactory test proposed for the presence of foreign fats in butter is the determination of the amount of soluble fatty acids in the sample. Butter contains, besides the stearate, oleate, and palmate of glycerine, about six or seven per cent. of the butyrate of glycerine. The acids of the first three bodies are insoluble in water, while the acid of the butyrate is soluble.

Pure butter fat should yield about 88 per cent. of insoluble acids and 6 per cent. of soluble acids; while all the other fats give about 94 to 95 per cent. of insoluble acids.

The examination is made by first melting the butter, and allowing it to settle while in the melted state. About three or four grammes of the pure fat are taken and saponified with a concentrated solution of potash. It will be found advantageous to use alcoholic potash for this purpose. When the saponification is completed, the soap is evaporated until the alcohol is driven off; it is then dissolved in water, and decomposed by dilute hydrochloric or sulphuric acid.

The fatty acids are then thoroughly washed with boiling water. This is most conveniently done at first by decantation, the water being poured on to the fat, which is placed on a separatory funnel or in a beaker; in the latter case the water is removed from under the fats by means of a pipette. When the fatty acids have been well washed, they are transferred to a weighed filter, the filter having been previously wet with water.

After the fatty acids have been completely transferred to the filter, it is placed on a watch-glass, and dried at 100° C. until it ceases to lose weight.

If the operation is carefully carried out, it gives good results.

Butter intended for the Boston market is very generally colored; this is done sometimes with carrot juice, but most commonly with some preparation of annatto. The color for this purpose is made by heating the annatto seed with caustic soda or potash. The seed produces a much brighter color than that obtained from the cake. An oil color has been recently introduced into the market, which is made from cotton seed or some other neutral oil, colored with annatto and turmeric; this color is preferred by many, since it does not color the buttermilk. The use of these various colors in butter is a fraud in so far as it is an endeavor to make pleasing to the eye an otherwise uninviting article. But it is a fraud which is sanctioned by long usage, and which is not only harmless, but adds to the comfort and pleasure of the user.

The use of substitutes for butter seems to be steadily on the increase in this country. When good butter is at from forty to fifty cents per pound, it has passed beyond the means of persons in moderate circumstances, and they have the choice of three things: to do without, to use poor butter, or to use some substitute.

It was, according to Mégé-Mouriez, a demand such as this which led him to investigate the manufacture of a palatable substitute for butter from the fat of animals slaughtered for food. By his investigations he was led to believe that the only difference between butter and beef-fat was that the latter contained an excess of stearine. He also came to the conclusion that the taste and smell of ordinary tallow were largely due to the want of care in its manipulation. He therefore prescribed the following method of procedure:

The caul fat was to be taken as fresh as possible, and to be thoroughly washed, then chopped fine and rendered with a dilute solution of acid phosphate of lime and the stomach of a pig or sheep at a temperature not exceeding animal heat. (This heat has been gradually raised in reissues of his patent until, at the present time, it reads, "at a heat not exceeding 125° F." It is not possible to do good work at a temperature below 116° F.) After the fat is completely liberated by this process, it is allowed to stand until the membrane settles; it is then drawn off into coolers, and allowed to granulate and to cool to a temperature of about 80° F. The fat is then placed in cotton-cloth press-bags, and submitted to a powerful press, the press-room being maintained at an even temperature of 80° F. The oleomargarine thus produced is free from any disagreeable taste or odor. It is in fact a pure tallow oil, suitable for use as an article of food; in this state it makes an excellent substitute for lard.

Such was the process as originally proposed by M. Mégé. The process as now followed is much more simple, and omits some of the objectionable features of the Mégé process.

In the first place, the fat, which is received warm from the slaughter-house, is sorted over, and all bloody pieces thrown out; it is then at once placed in cold fresh water, where it is thoroughly washed. From this water, which not only washes it but serves to cool it, it is at once taken to hashing-machines, similar to the ordinary sausage-cutters, where it is cut into fine pieces. From these machines it falls at once into the rendering tanks, where it is rendered at a heat varying from 160° to 200° F.; the object being to separate, as quickly as possible, the fat from the membrane. No "gastric juice" or phosphate of lime is used. After the fat is well cooked a quantity of salt is added; this serves to separate the membrane more completely. After standing a few minutes the fat is then run off into barrels or other vessels, where it is allowed to settle, and is crystallized. When it has cooled to about 95° to 100° F., it is pressed in the usual manner.

After pressing, the oil is churned with milk or buttermilk, some genuine butter being frequently added; it is colored properly, and then run into ice-water or pounded ice, so as to prevent its crystallization; after this operation it is worked as ordinary butter.

When well made it is a very fair imitation of genuine butter; being inferior to the best butter, but much superior to the low grades of butter too commonly found in the market.

So far as its influence on health is concerned, we can see no objection to its use.

Its sale as genuine butter is a commercial fraud, and as such very properly condemned by the law.

As to its prohibition by law, the same law which prohibited it should also prohibit the sale of lard and tallow, and, more especially, all low-grade butters, which are far more injurious to health than a good, sweet article of oleomargarine.

A great deal has been said in regard to the poor grade of fats from which the oleomargarine is made. Any one making such assertions in regard to the fats is simply ignorant of the whole subject. When a fat has become in the least tainted, it can no longer be used for this purpose, as it is impossible to remove the odor from the fat after it has once acquired it.

IMPURITIES IN METALS.

PROFESSOR W. C. ROBERTS-AUSTEN, F.R.S., lately delivered his third lecture at the Royal Institution upon "Impurities in Metals." He said that he would first consider how molten masses of metals deal with the impurities they may contain. Lead in gold seems to be uniformly distributed, and the same is the case with alloys of lead and arsenic; but such is not the case with all alloys. Some metals tend to throw out impurities, just as the ice in freezing water tends to do the same with certain aqueous impurities. Matthieson years ago, in the theater of the Royal Institution, gave evidence in relation to some alloys which are uniform and others which are not so. In the latter case the metals seem to drive the impurities toward the center of the mass. In this way what the alchemists called "the regulus of Venus," which is an alloy of copper and antimony, tends to reject lead by driving it to the center. Professor Roberts-Austen illustrated this by placing a disk composed of the said three metals in the focus of the objective of the electric lamp; and when he pushed the center of the disk, as represented in the accompanying cut, it fell out, leaving the representation upon the screen of the exterior ring of alloy, which had thus rejected the lead. Iron in the Bessemer ingot, he said, behaves somewhat in the same way—the sulphur and phosphorus are driven to the center of the mass, and for good iron the exterior portion only should be utilized. Iron containing carbon in solution allows it to separate in graphitic form, unless the cooling be rapid; in the latter case, white iron is the result. Cast iron and steel have mechanical and physical differences. He illustrated this by calling attention to a section of a hollow propeller shaft, made of compressed

steel, and said that if a shaft of the same strength were to be made of wrought iron it would have to be 28 per cent. heavier, and solid. He said that there is no very hard and fast line between the different kinds of iron and steel—wrought iron contains $\frac{1}{10}$ per cent., or a little over, of carbon; watch springs contain about $\frac{8}{10}$ per cent., and the dies used at the Mint $\frac{8}{10}$. The accompanying table, he said, gives some idea of the relative proportions:

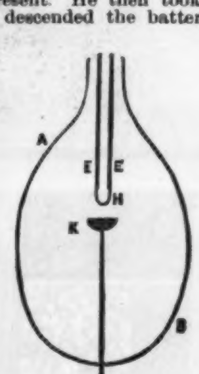
	Iron.	Steel.	Cast Iron.
	Per cent.	Per cent.	Per cent.
Bergmann, 1781......	0·12	0·5	2·2
Modern view.........	0 to 0·15	0·15 to 1·5	1·5 to 3·8

Cast Iron.

	Gray.	Mottled.	White.
	Per cent.	Per cent.	Per cent.
Combined...	0·08	1·43	3·17
Carbon, graphitic or free............ ...	3·40	2·02	0·12
Total..........	3·48	3·45	3·29
Combined............	0·18	1·14	1·93
Carbon, graphitic or free...............	2·45	1·50	0·55
Total	2·63	2·64	2·48

The speaker next stated that Reaumur, in 1722, first noticed the black spot produced upon iron by nitric acid, and Bergmann, in 1781, made known that carbonic acid would give up carbon to iron. Clouet, in 1796, made steel by heating a diamond in an iron crucible. But the results of such experiments varied greatly in different hands, and left the question open whether furnace gases might not have had a share in the results.

In 1815 Mr. W. H. Pepys, a working cutler and a member of the Cutlers' Society of London, was the first to exclude furnace gases from the experimental solution of the problem. He heated an iron wire with an electrical battery, keeping the wire from contact with air, and, by bringing the hot wire in contact with a diamond, made steel, thus setting the problem to rest forever. Margueritte showed, in 1865, that contact with carbon is sufficient to produce the carbonization of iron. He placed three diamonds on a thin film of iron, displaced by hydrogen the air in the containing tube, and when the arrangement was heated the diamonds fused their way through the iron. He (Professor Roberts-Austen) had repeated Margueritte's experiment at the Mint, the furnaces at the Royal Institution not being suitable for the work, and he would show them the result in the piece of iron through which the diamonds had passed, turning some of it into steel. He added that he would, however, perform the experiment of turning malleable iron into steel by means of diamond dust in such a way that it should be visible to all present. He then took the glass vessel, A B, in which descended the battery terminal wires,



E E, connected at the ends by the loop of fine malleable iron wire, H. The little vessel, K, below contained diamond dust. The glass vessel could have been exhausted of air, if desired, but he said that he did not exhaust it simply because it would complicate the experiment. The loop, H, was then made white hot by an electrical current, and brought into contact with the diamond dust, K, when it at once fused into globules, where the contact was established. The speaker said that he could heat the globules, cool them under mercury, and then show that they would scratch glass, consequently that they consisted of true steel; but he thought that the time allotted for the lecture could be better utilized. He then said that he would exhibit a method of separating carbon in the sooty form from iron in a way not perhaps generally known. He took a little square plate of compressed fused chloride of silver, as transparent as glass, and on it placed a fragment of steel; then upon both he dropped a little hydrochloric acid; the piece of iron was then slowly dissolved into chloride of iron, and the carbon, he said, was left in the sooty deposit remaining. As to the probable relations between carbon and iron, conflicting evidence was given by chemists, but Sir Frederick Abel had satisfied himself that under certain conditions a carbide was formed. In hard steel, however, appearances seemed to indicate that the carbon was in actual solution.

The lecturer added that a few years ago the Institute of Mechanical Engineers appointed a committee to investigate the properties of steel, and that some of the experiments of the committee had been anticipated by Reaumur in 1722. Reaumur proved that steel gave out no gases when heated in a Torricellian vacuum. At present, he said, it is not absolutely necessary to resort to chemical analysis to determine the constituents of different varieties of steel, for Professor Hughes has devised a plan of classifying steel by measuring its magnetic capacity, a quality which depends mainly upon the amount of carbon it contains.

In his last lecture, he said that the subjecting of metal wires to incessant vibratory strains until breakage is effected, and registering the number of vibrations given until that point is reached, will sometimes indicate the presence of impurities in such minute proportions as to be altogether beyond the range of discovery by chemical analysis. In order to remove certain impurities from metals, it is sometimes necessary to add other impurities to them, in order to give an inducement to quit to the impurities originally present; thus arsenic has sometimes to be added to copper, to help to get rid of nickel or cobalt. Zinc is sometimes added to molten lead, and the zinc, rising through the lead, will carry up with it any silver present in the latter metal, leaving the "mother lead," if so it may be called, sensibly purer; the silver is afterward separated from the zinc.

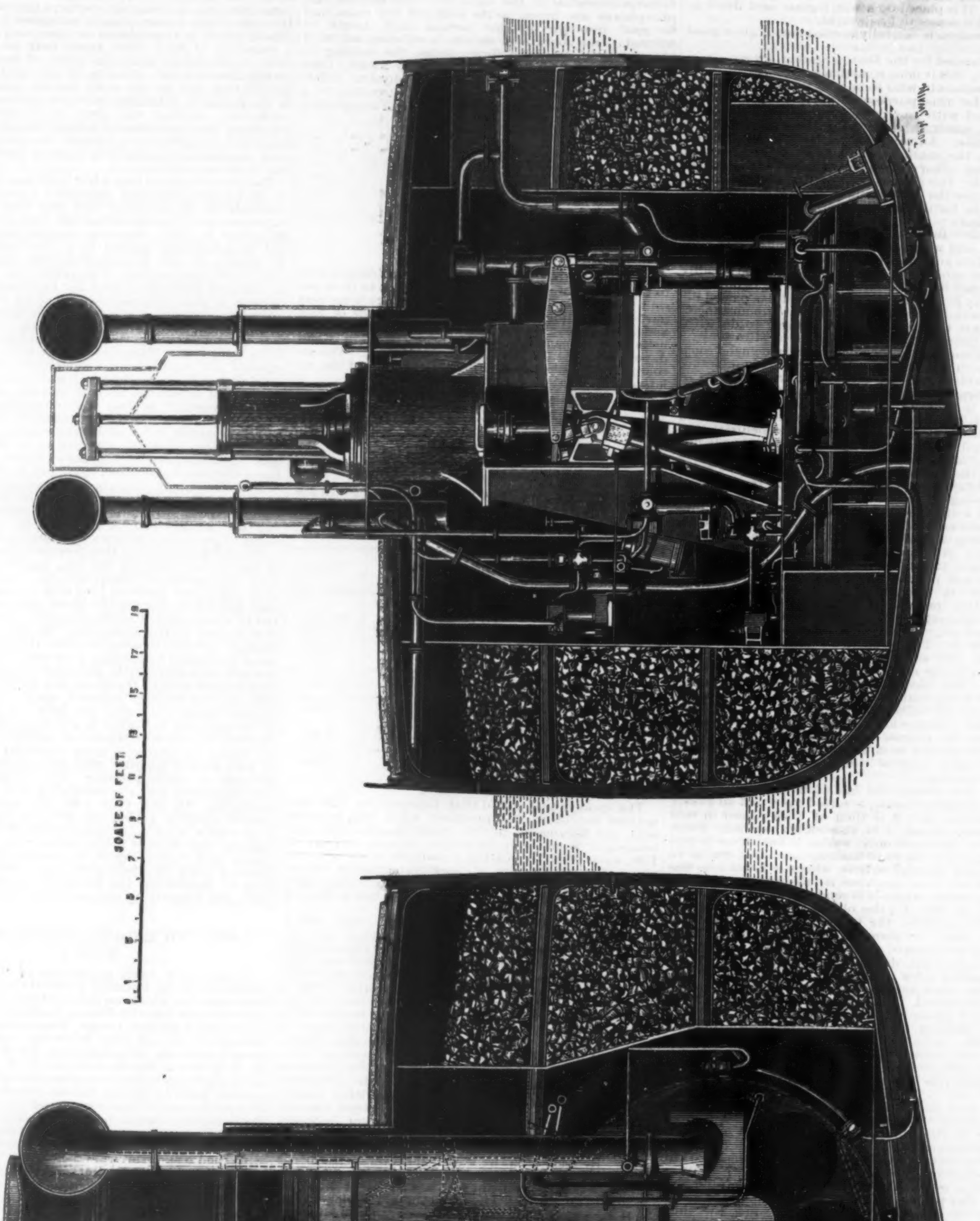
The ancients believed that Nature is the great purifier of metals, and that by the long agency of time and heat she gradually transforms the baser metals into gold; they also believed that man arrests this beneficent process by digging the latter metals prematurely out of the ground. Chlorination, or "trial by cement," was known to the alchemists. If gold contains just enough silver to destroy its color, they found that the color is restored by heating it for seven or eight days in contact with clay, earth, salt, and vinegar. The chlorine formed attacks the silver and carries it off as chloride, leaving the gold unacted upon, because chloride of gold cannot exist at a red heat. When an alloy of silver and gold is heated in a current of dry chlorine, chloride of silver is separated, and the gold remains. He then took some gold made brittle by an admixture of lead, melted the alloy, and sent a current of chloride through it under pressure. The volatile chloride of lead separated, and the remaining gold was rendered malleable. In the year 1869, he said, he purified £40,000 worth of gold at the Mint by this process. He next took a solution of chloride of gold in water containing also salts of other metals; he added a little oxalic acid to the liquid, it separated the gold and threw it down in a very pure state. He closed his lecture by describing the Bessemer process of making steel, and illustrating various points by experiment.

COMPOUND ENGINE OF THE S.S. PROMETHEUS.

WE give this week engravings of the engines and boilers of the s.s. Palamid, Prometheus, Palinurus, and Dardanus, for which we are indebted to the *Engineer*. These vessels, built by Messrs. Leslie & Co., of Hebburn, to the order of the Ocean Steamship Company, of Liverpool, are of the following dimensions, viz.: Length between perpendiculars, 320 ft.; beam moulded, 36 ft. 4 in.; depth moulded, 27 ft. 9 in.; and will carry about 3,000 tons on a mean draught of 23 ft. The engines, built by Messrs. Robert Stephenson & Co., of Newcastle, are of the compound surface-condensing Holt's tandem design, having cylinders 27 in. and 58 in. diameter, with a stroke of 5 ft., the high-pressure cylinder being placed immediately over and concentric with the low-pressure cylinder.

The high-pressure piston rod is attached to an overhead crosshead, from which side rods come down outside of the high-pressure cylinder, and passing through glands in the low-pressure cover are attached to the low-pressure piston. This arrangement obviates the necessity of having glands to pack between the two cylinders, and consequently considerably reduces the height from bed-plate to top of cylinder. The low-pressure piston rod is fitted with a wrought iron crosshead and cast iron adjustable shoes as shown, and through its connecting rod transmits the power of the two cylinders to the crank pin. All the piston rods and the slide spindles are of steel. The low-pressure slide valve is of the ordinary type, the high-pressure cylinder having a piston valve fitted with Buckley's patent springs and rings; both valves are worked by the same pair of eccentric rods, and the usual Stephenson's link motion. The reversing is effected by a steam cylinder controlled by an oil cataract fitted to the back of the column as shown.

A special feature of these engines is the crank shaft, which is of the "overhung pin" description. The shaft itself is of Vickers' steel, 14 in. diameter, having the eccentric sheaves forged on solid immediately behind the thrust collar. The crank check is of wrought iron, contracted and keyed on the shaft and fitted with a crank pin also of Vickers' steel contracted in and further secured by a strong steel key as shown. It is anticipated that by the adoption of this form of overhung crank, the many vexatious and costly breakages of crank shafts will be very much minimized, and the delays and dangers occasioned thereby correspondingly reduced. The engines are fitted with a five-ton flywheel of somewhat novel construction; the heavy outside rim is of cast iron suitably bored and faced to receive the center, which consists of one large steel plate 8 ft. 4 in. diameter by 2 in. thick. This plate is turned and faced up and bolted to the inside of the wheel rim, and secured between the two large couplings of the shafts as shown by tight fitting taper bolts, each shaft



ENGINE AND BOILER OF THE S. S. PROMETHEUS.

coupling having spigots which meet in the center of the plate. This wheel, besides being an excellent governor to the engines, is used for turning and overhauling the engines when cold by means of a steam cylinder and oil cataract attached to the bulkhead just over the fly-wheel.

The piston rod of this heaving-round engine is square in section at the center, and slotted through to receive strong steel pawls, which gear into suitable teeth cast in the rim of the fly-wheel for go-ahead or go-astern motion as required. The screw shafting is of wrought iron cased with brass where working in *lignum vitæ* bearings in the stern tube, and fitted with a four-bladed right-handed screw propeller of cast iron, 15 ft. 9 in. diameter, and 20 ft. 6 in. mean pitch. The condenser is of the usual form, of cast iron, fitted with brass tube plates and tubes. The length between the tube plates is 7 ft. 10 in., and the diameter of the tubes is 1 in. outside, with a total cooling surface of 1,925 square feet. The tubes are divided into three boxes, through each of which the water must pass, thus coming thrice into contact with the steam before being delivered overboard. The water is forced through the tubes by one double-acting circulating pump, 13½ in. diameter by 22½ in. stroke, attached to the back of the condenser, and so arranged that all or any of the valves may be examined or overhauled without interfering with each other or with any other part of the machinery. The air-pump is of the usual single-acting description, 18 in. diameter by 22½ in. stroke. The feed and bilge pumps are placed in line on the back of the condenser, the feed pumps above and the bilge pump below the pump crosshead, the top part of the condenser being utilized as a hot well into which the air pump delivery is conducted, and from whence the feed pump draws for the boiler. The feed and bilge pumps are each 5½ in. diameter by 22½ in. stroke, their valves also being arranged for instant and easy access. A single-acting plunger pump for supplying water to the fresh-water condenser is fitted to the after side of the condenser column and worked from the air pump lever as shown.

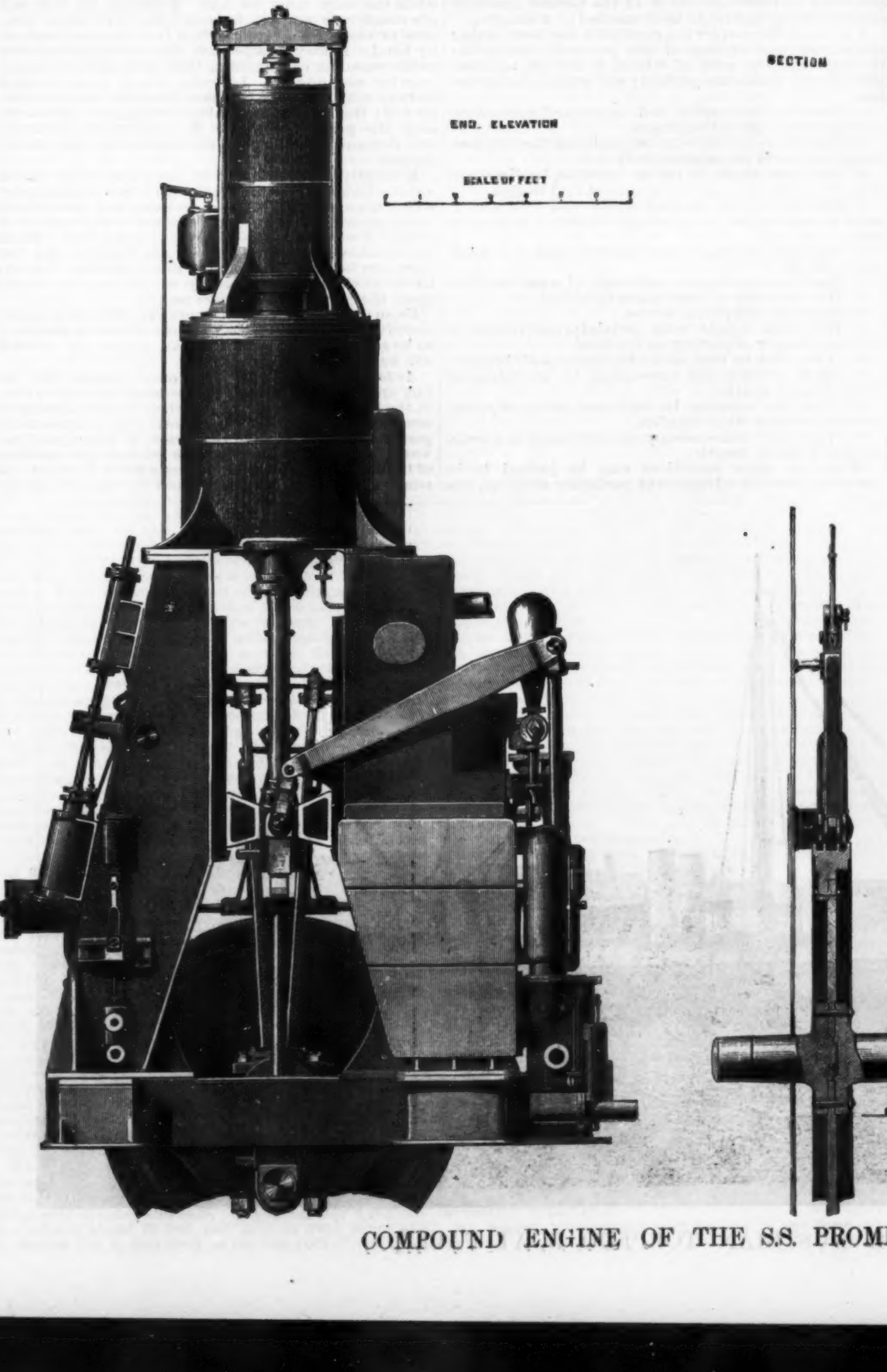
A double-acting donkey pump for feed and deck-washing purposes is attached to the forward side of the column and also fitted with connections for delivery through the condenser in case of necessity. The starboard column, besides carrying the reversing engine and gear, is further utilized as an oil tank. At the level of the starting platform a 6 in. Gwynne engine is fixed, and connected to draw from the bilges and deliver overboard, being supplied with steam from either the main or donkey boilers, so as to be available in case of emergency; supposing the pumps on the lower platform should be disabled or drowned out, this engine gives great additional security to life and ship.

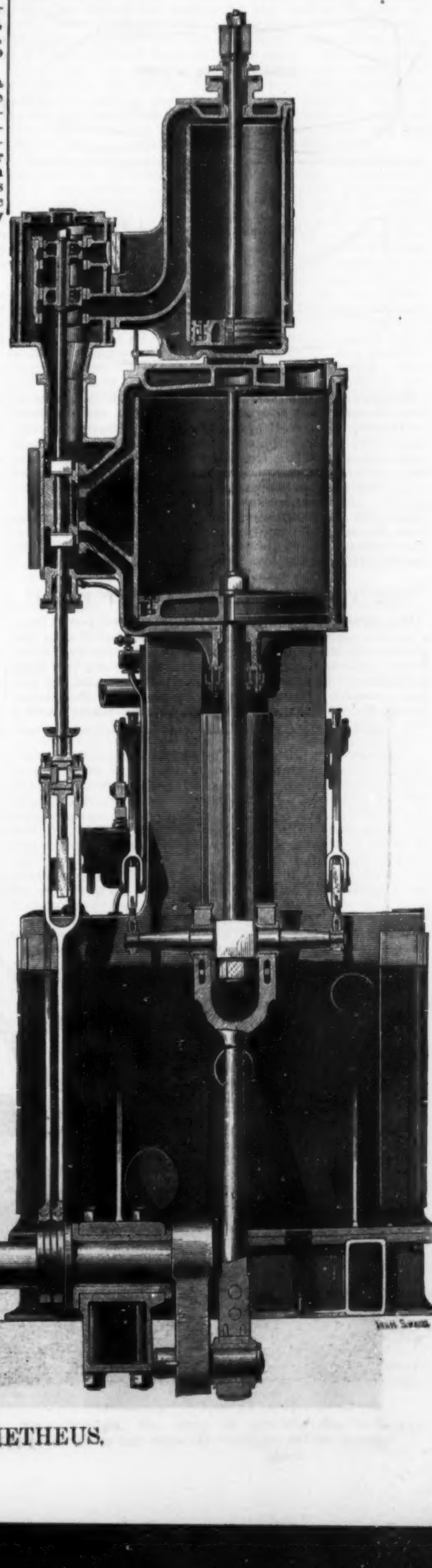
Steam is supplied by one double-ended steel boiler 16 ft. diameter by 24 ft. long, working at 80 lb. pressure per square inch, fitted with six Fox's corrugated steel furnaces. These furnaces, three at each end, lead into a central combustion chamber, thence by return tubes to the smoke-box and chimney. The shell of the boiler is butt-jointed, with double butt straps, double riveted in the longitudinal seams, and lap jointed and double riveted in the circumferential seams. The holes are all drilled, then properly reamed in place after the plates are fitted together.

The heating and grate surface of the boiler is as follows: Heating surface in tubes, 4 in. outside diameter, 9 ft. long, 4,015 square feet; heating surface in furnaces, 420 square feet; heating surface in flues and tube plates, 580 square feet; total heating surface, 5,015 square feet; total grate surface, 153 square feet. Chimney, 7 ft. 6 in. diameter by 65 ft. high from the grate bars. The total weight of the boiler with water in and fittings complete, in working trim, is 157 tons. The engines in regular running develop on the average about 1,350 indicated horse-power, with a very moderate consumption of fuel, and an average speed of about twelve knots an hour.

The engravings supplied give a very clear idea of the whole of the general arrangements, which, carried out under the supervision of Mr. S. W. Wiles, the superintendent engineer for the Ocean Steamship Company, are of the most complete and satisfactory description, both as regards efficiency and safety and comfort to those in charge of the machinery.

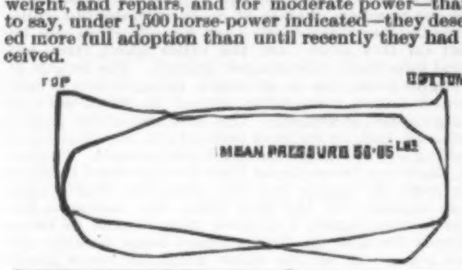
The single type of marine engine has long been a specialty with Mr. Holt. Years ago we illustrated the engines of the s.s. Teniers. That which we now illustrate here and on pp. 8618 and 8620 is the latest development of the design, and was in its main features described by Mr. F. C. Marshall in his celebrated paper "On the Marine Engine," read before the Institution of Mechanical Engineers, in Newcastle, in 1881. It has slowly made its way into favor by dint of its intrinsic merit. Mr. Holt's view is that a marine engine is very like any other engine, and that as single-crank engines answer very well on land, they ought also to answer at sea. It will be observed that the engine is very lofty, but this is of no consequence in a merchant vessel, and there are numbers of ships at work with double-crank double-tandem engines, so that no objection can be raised on this score. On the other hand, there are several important advantages gained. The length of the engine-room can be so much reduced that a considerable saving, amounting indeed to 200 or 300 tons of cargo space, is secured. The first cost of the engine is reduced, and, as we have pointed out, the chances of breaking a crank-shaft are much diminished. Besides this, there can be no doubt that the fly-wheel tends to spare both the engine and the propeller shaft many severe strains. In the first place, the engine is less likely to race; again, if it does race, instead of being suddenly brought up, the fly-wheel helps to keep the screw going. If, on the other hand, the screw jumps out of the water, the fly-wheel interposes its inertia, and tends to prevent the engine running away. The turning movements are, of course, irregular, but this does not seem to be felt in the engine-room or by the screw, the engine running as smoothly as any other. The only objection we have ever heard seriously raised is that the engine is very unhandy, being likely to stop, to stick on the top or bottom center. There can be no doubt that some practice is necessary to handle the engine properly; but we know by personal experience that an engineer who is familiar with the Holt engine can handle it going into or out of port without ever getting it stuck on the center, and even if it did

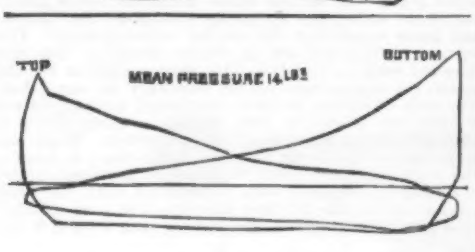


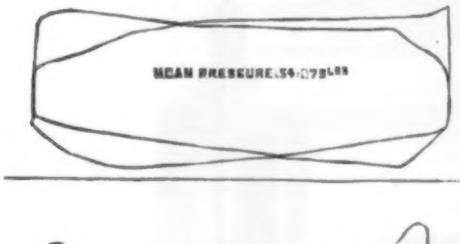


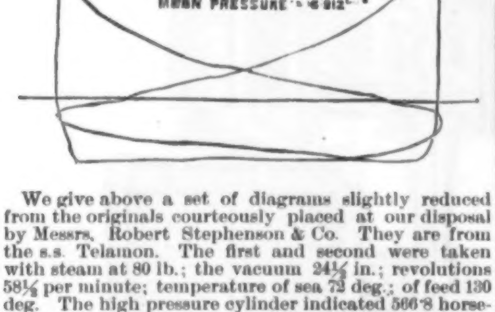
COMPOUND ENGINE OF THE S.S. PROMETHEUS.

stick, one stroke of the heaving-round engine will start it again without a perceptible delay. These engines have proved themselves economical in fuel, dead weight, and repairs, and for moderate power—that is to say, under 1,500 horse-power indicated—they deserved more full adoption than until recently they had received.





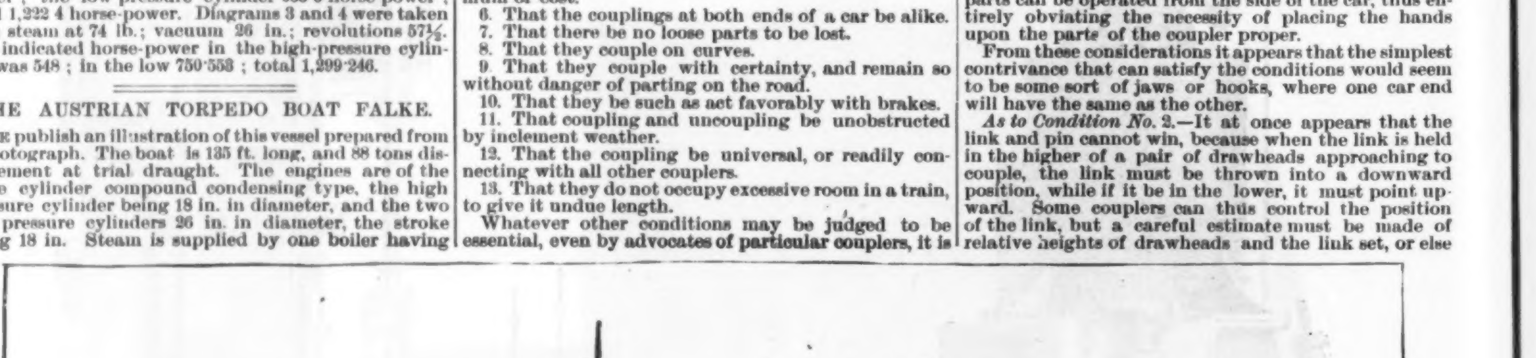




We give above a set of diagrams slightly reduced from the originals courteously placed at our disposal by Messrs. Robert Stephenson & Co. They are from the s.s. Telamon. The first and second were taken with steam at 80 lb.; the vacuum 24½ in.; revolutions 58½ per minute; temperature of sea 72 deg.; of feed 130 deg. The high pressure cylinder indicated 566·8 horse-power; the low-pressure cylinder 655·6 horse-power; total 1,222·4 horse-power. Diagrams 3 and 4 were taken with steam at 74 lb.; vacuum 26 in.; revolutions 57½. The indicated horse-power in the high-pressure cylinder was 548; in the low 750·553; total 1,299·246.

THE AUSTRIAN TORPEDO BOAT FALKE.

WE publish an illustration of this vessel prepared from a photograph. The boat is 135 ft. long, and 88 tons displacement at trial draught. The engines are of the three cylinder compound condensing type, the high pressure cylinder being 18 in. in diameter, and the two low pressure cylinders 26 in. in diameter, the stroke being 18 in. Steam is supplied by one boiler having 2,000 square feet of heating surface and 44 square feet of grate surface. The coal bunker capacity is 28 tons, and the draught on trial 2 ft. 3 in. forward and 5 ft. 6 in. aft. Two of these vessels were built for the Austrian Government. They left Greenhithe on the 18th of last February, and duly arrived at Cagliari, stopping several hours at Oporto, where they arrived in February, to take coals and stores on board.—*Engineering.*



THE AUSTRIAN TORPEDO BOAT FALKE.

CAR COUPLERS.

By Prof. S. W. ROBINSON.

IN the forthcoming report of Mr. Hylas Sabine, Railroad Commissioner of Ohio, will appear a chapter on car couplers, by Prof. S. W. Robinson, for four years one of the inspectors of railways in that State. We append this chapter in full, as follows:

The prevailing car coupler of to-day, viz., the "link and pin," might be classed with hand brakes as among those parts of railroad equipment for which no considerable improvements have been adopted since railroading began. This is, however, no fault of inventors, as the thousands of patents on couplers and the numerous patented couplers of high merit will testify. While inventors wonder why their couplers cannot be introduced, railroad men falter at undertaking so great a task. One serious drawback in the way of introduction is the difficulty in deciding upon the adoption of an acceptable coupler from the many offered, State commissions and committees of societies of high standing, appointed to make selection, not being able to decide in favor of any one coupler. Such indecision is probably in the way of progress in this matter, and due partly to the fact that a coupler adopted by any one road should couple readily with that in use on any other road.

No one denies the need of a new coupler for general use by which the numerous grave evils of the "link and pin" shall be avoided, evils which are greatly intensified by the increased weight of car loads, and which show up this old coupler as founded upon a most thoroughly unscientific basis. Increasing agitation of the coupler question indicates that the time is now near at hand when a move *must* be made, and that the old coupler "must go," and be tried for all its sins scored in the loss of thousands of human lives and untold damage to property in transportation, and that the coming coupler will be hailed with greater or less acceptability according to fulfillment by it of the various qualities and conditions rightly to be demanded of a coupler.

A study of the coupler has resulted in the formulating and announcing of some of the points of demand in the new coupler, most of which, if not all, together with others, which are probably self-evident, are given here:

1. That they be coupled and uncoupled without requiring men to go between cars.
2. That whatever the relative heights of the couplers, they couple and uncouple equally well.
3. That free slack, as far as possible, be dispensed with, to reduce damage to equipment and freight.
4. That cars can be coupled easily and with a minimum of concussion, to encourage careful handling of cars.
5. That they be simple and durable, and at a minimum of cost.
6. That the couplings at both ends of a car be alike.
7. That there be no loose parts to be lost.
8. That they couple on curves.
9. That they couple with certainty, and remain so without danger of parting on the road.
10. That they be such as act favorably with brakes.
11. That coupling and uncoupling be unobstructed by inclement weather.
12. That the coupling be universal, or readily connecting with all other couplers.
13. That they do not occupy excessive room in a train, to give it undue length.

Whatever other conditions may be judged to be essential, even by advocates of particular couplers, it is believed that there can be no reasonable objection to the above as general essential conditions. And further, it is believed that the coupler which answers to the greater number of the above conditions, giving preference to the first ones in order, is the coming coupler.

An inquiry as to the value of this coupler will probably bring out points of consideration about as follows:

First, for No. 1, *relative to men going between cars* to work the couplers. No one will deny that it is very dangerous for the men that do it. Too many men are killed this way, and known to be, to admit of any argument. Relative to this danger, railroad men seem to look at this matter of retaining an old coupler as does a general in an army to take a fort; it costs the lives of men to do it, and the general regrets this because it leaves him less able to secure further trophies. The railroad man regrets the cost of lives at the coupler, because new men, seeing the danger, demand higher wages, and families of those sacrificed demand compensation, pension, etc. Money being the object of railroads, the pensions are regretted, while the lives sacrificed are another matter. Doubtless, individual officers of roads regret this extravagance of human life, but the officer must act for the company, to be a good servant, and it is the company that has no heart. When a coupler comes that costs the company no more money, all things considered, the road will doubtless adopt it. It may be influenced a little by the life consideration, but for a venture it is safer that the coming coupler be so commendable as to leave out the life consideration. But, from a humane standpoint, let the new coupler satisfy No. 1.

As to what is understood by "going between cars," in coupling or uncoupling, it should be taken in its broadest sense; that is, the coupler should not require the men to even step between the rails for uncoupling, or to place a link and pin, or a jaw or hook, in position to be ready to couple when the cars come together. Many couplers claim to not require the operator to go between cars, overlooking the fact of getting a coupling ready by going between cars or in front of the car. But this is to be avoided, because men will do this while a car is in motion approaching another to be coupled, when catching of the foot in a frog or switch will be fatal.

Evidently the "link and pin" must be ruled out for No. 1 condition, because in coupling two cars there may be present in the drawheads two links or none, while one only must be had. Probably the link and pin coupler is not yet invented that will either produce or vanquish a coupling link to a drawhead except by hand. It may be said that the man may run over to the standing car, avoiding the one in motion, to prepare for coupling up. Likewise, a man going along a railway may not walk between the rails, but for a fact he will; that is, men will submit to danger to get easily over the present moment. It is, therefore, better to not demand the duty which can in any way entail danger.

Evidently, the best way to meet No. 1 is to throw out the link and pin, and substitute an arrangement which always has all its parts present, and from which nothing can be removed, and which is at the same time a copy of what is on the car to be coupled with. Then by suitable connecting rods, chains, handles, etc., the parts can be operated from the side of the car, thus entirely obviating the necessity of placing the hands upon the parts of the coupler proper.

From these considerations it appears that the simplest contrivance that can satisfy the conditions would seem to be some sort of jaws or hooks, where one car end will have the same as the other.

As to Condition No. 2.—It at once appears that the link and pin cannot win, because when the link is held in the higher of a pair of drawheads approaching to couple, the link must be thrown into a downward position, while if it be in the lower, it must point upward. Some couplers can thus control the position of the link, but a careful estimate must be made of relative heights of drawheads and the link set, or else

the link must be directed while the cars approach to couple—either requiring complication of mechanism and of operation. Jaws or hooks which swing about a vertical axis and quite deep in the vertical line of direction, and of uniform figure throughout that depth, will meet the condition No. 2 perfectly, provided the difference in height is not more than the depth of jaws. This depth, then, must be great enough to provide for all such variation in height as is due to yielding of car springs for all loads, wearing of axle brasses, setting of springs, wear of bolsters, wear of carrying plates, etc., as well as variations in adopted heights of drawbars in new cars. Such hooks will give the best conditions of draft, a higher drawhead not tending to lift a lower one, or to raise a car end off its truck, nor to jerk the truck upward off the track. In the hooks described, each car will carry its own load perfectly as far as couplers are concerned. This is especially favorable in places where the track is not in exact "surface," or where variations in surface are intended, as in case of the Wharton switch, in which instances the hooks may slide vertically in each other.

By the free slack in the third condition is meant the same as in the discussion of brakes. The link and pin is an example of a coupler where a considerable free slack is prevalent. This has been considered as essential for operating trains in order to start a train from a standstill. It is known that the resistance in starting is greater than the resistance in motion of a train. With two inches of free slack a train of thirty cars will be five feet shorter when the drawheads are in contact than when drawn out to bearing of links upon the pins. Thus, when a train is fully "slacked back," if the locomotive starts to energetic pulling, the cars will be pulled out, one at a time, with a violent jerk for each. These jerks are sufficient to move freight about in the cars, worry live stock, throw brakemen from the cars, etc.

Railroad men may suppose that the jerks constitute an undoubted railroad "license," but the license is a source of much damage, as evinced by such facts as that live stock shipped from Chicago to New York by the cars of the Palace Stock Car Co. is worth more cents per pound, and that the stock is sought by butchers in New York in preference to that shipped by jerks; also the fact that fruit trains over the Chesapeake and Ohio required that the rear part of the air brakes be cut out in long trains to avoid the jolting and damaging of the fruit in transit, and in the case of shipment of household furniture, on arrival it was found out of place and tipping over in consequence of the free slack. The first road that abandons free slack will find its revenues increased in consequence. Then it is that other roads will be obliged to run minus free slack.

There is intrinsically much more deprecation of the free slack than people usually are aware of. When danger occurs from it, it is to some extent submitted to without murmur instead of being blown all over the country by the papers, because thoughtlessly looked upon as an unavoidable concomitance of freight trains.

As to the necessity for slack, there seems to be a demand for it, from the fact that the starting resistance of trains is well known to be much greater than the running resistance. Thus, a passenger train of twelve cars appears to be about all that a locomotive can start with on a mild up grade, when the same engine can take the same train, making time, over all grades of the line. In freight trains, it is probable that a locomotive can haul a train over the line which is fully twice as long and heavy as one that it can start from rest without slack.

But that the slack that seems to be so essential must be "free slack" is to be denied. Trains are already equipped with Janney couplers with no other appreciable slack than what might be called "elastic slack," and got from the springs of the drawbars. In these there are the draught springs and the buffer springs, the former resisting the drawing out of the drawbar, and the latter the compression of it. Now, if a drawbar will pull out three inches and go back two inches, there will be five inches of elastic slack. With this the trains mentioned have been able to start readily. By pushing back at the front end of a train, the first spring is compressed to move that car; then the next car is moved by compression or spring, then the third, etc., until finally the last car is on the point of starting back. Then the compression of the springs along the train is different, and diminished from a maximum at the engine to a minimum at the caboose. Now, if the engine reverses and pulls, the spring resistance at each car will be reversed one after another, the last occurring when the caboose is on the point of starting. The forward cars then will have considerable motion, due to the drawing out of about six or eight feet for a train of thirty cars, and probably enough for starting this or any train the locomotive can take over the line.

In the link and pin coupler there will be the free slack and a small amount of elastic slack, and both together may be somewhat in excess of that for the Janney, Dowling, and other couplers as described; but the free slack, in consequence of the slacks and concussions due to it, is very uneffective, from the well-known principle in mechanics that in shocks and collisions there is always a loss of energy. Thus, when one mass with a certain velocity collides dead with another equal mass at rest, half of the energy of motion is lost. A ball will not roll near as far on a cobblestone pavement when let go with a given velocity as it will along a smooth floor where there are no shocks or knocks. And so in trains of cars since the introduction of smooth steel rails, tractile resistance has dropped from six to eight pounds per ton for iron track to three or four for steel. Likewise, much less energy is lost with the smooth elastic slack than with the free slack, which jerks cars and couplings to pieces and destroys freight. Again, it is plain that these destructive effects can be only the result of work performed. This work comes from the locomotive, and is thus consumed in tearing the train goods to destruction instead of doing what was intended, viz., starting and hauling the train. Then away with this monster of destruction, free slack, and adopt that class of slack that is based on rational and scientific principles!

What has been said of the destructiveness and extravagance in power of free slack, as connected with the starting train, is also true of trains out on the line, going over summit and sags. In pulling over a summit in grades of about 20 feet per mile or over, there will be shocks due to free slack as the last part of the train leaves the summit, with consequent destructive effect, but power will be plenty on the declivity. But in moving out from a sag, shocks will occur as the slack between succeeding cars pulls out, consuming power for destruction and damage that is needed for pulling the train, and perhaps causing partial fractures of links or pins, which on the up grade may part, with calamitous consequences. Probably one-fourth of the "wear" of three-fourths of the "tear" in freight rolling stock is due to free slack. All these destructive effects are only to be avoided by running with close couplings, and introducing a sufficiently liberal amount of elastic slack to admit of ready and convenient operating of trains.

In attempting the reduction of free slack to a minimum, the link and pin will be found a hard customer to deal with. So many conditions affect the slack in this case that a safe minimum cannot be placed lower than one or perhaps one and a half inches. Some of these conditions are: 1. Links and drawheads must be capable of universal interchange between the various roads where drawheads and lengths of link will differ, and a sufficient allowance must be made in the free slack, so that coupling up is always possible. If these parts are not "standard," that is, all nominally the same, the free slack will sometimes be greater than above stated. 2. Varying heights of drawbacks will cause the link to be inclined, and thus require extra length. 3. Difference in size and bending of pins will vary the free slack, and bent pins are common. 4. Wear of face of drawhead and of pinholes will increase the free slack.

Any substitute for links, like double-ended spearheads or double eyebolts, etc., which may take variously inclined positions, must be provided with extra length, the same as the link and pin, and always counting in the free slack. In all of these there are five dimensions to be provided for, each of which will vary, viz., from end of drawbar to pinhole, two; length of link, one; diameter of pin, two. Besides these there is the inclination, making a sixth provision in all.

But in the hooks on the Janney and Dowling principle, where there is nothing to become inclined, there are only two dimensions to provide for, viz., the thickness of hook, one, and the thickness of the space which embraces the hook, one, and no inclination, altogether only two provisions. From these facts there can be no hesitation in deciding that hooks, the shapes of which appear only in a horizontal plane, are the only practical coupling devices which can realize to us those modern ideas of slack which are based on reason, science, and economy.

Relative to No. 4.—If couplings depend on cars being brought together with force sufficient to close up the couplers, whatever their nature, then it is evident that this force should be slight, for the same reason that jolting of cars while in motion should be reduced to a minimum, viz., that freight may be handled carefully. If couplers require severe concussion to make them close up, the fact will encourage rough handling of cars, and managers cannot issue effective orders against it.

As to No. 5, it would appear from what has already been said that the free slack should be dispensed with for durability of couplers. Broken links, pins, and drawheads around yards stand to witness against free slack. That free slack is responsible for havoc, take the fact that a locomotive can only exert a pull of about 15,000 to 20,000 pounds, and compare it with the 150,000 pounds resistance of a link of 1¼ in. iron, a seven to ten fold greater value; even reducing the link to the resistance at the elastic limit, its strength would be five times greater than the dead pull of an engine. How, then, are links broken? The answer is, not by elastic slack, but by the jerks born of free slack. To illustrate, suppose a loaded car with total weight of 40,000 pounds started by jerk from a standing position in a train, and given at once a velocity of three feet per second, it will contain stored up in its mass 5,625 foot pounds of energy. A draught spring of 8,000 pounds, yielding three inches, to come down solid will consume, in being drawn down solid, 1,000 foot pounds. This, taken from the above, leaves 4,625 foot pounds of stored energy. Now, the drawbar will pull dead against the car timbers; and if we allow that the timbers yield one-half an inch to the jerk, the tension on link must be about 110,000 pounds, which is considerably above the resistance of the coupling link at the elastic limit, viz., 75,000 pounds. A link cannot stand many such jerks. But in the absence of free slack no such jerking can occur, so that a comparatively weak hook coupling without slack will be durable. Thus, with hook couplers devoid of free slack, drawheads and bars can be made much lighter than the devices at present in use; but while introducing them, and while link and pin couplers are still prevalent, the hook couplers must be much stronger and heavier and consequently more costly than after the link and pin disappears. When hook couplers are thus relieved of those intense strains unavoidable in the link and pin, they will be found to be unnecessarily heavy. They may be relieved considerably, and yet possess lasting qualities as well as lightness of weight. They may be made of steel castings, and hence not expensive.

For No. 6 nothing need be said here. It will be admitted by every one for all couplings.

The same for No. 7, in a general way, would be admitted by all disinterested. Is it possible that any can be so biased toward the link and pin as to insist that with it there are no loose parts to be lost? Extra links, good, bad, and indifferent, strewn about a yard may be held to not be lost. When two cars approach to be coupled, if each drawhead has a link, one must be removed; or if neither has a link, one must be forthcoming. In one case the link taken out may be lost, and in the other one may be found, and as long as these two demands neutralize each other, all goes well. Of course, much of this may be provided against by a rule that the west one or south one of the two pins must be drawn when uncoupling for remaking trains or discharging cars. But a run to the caboose for a pin or a link must occasionally be made, whereas, with those couplings, such as hooks, where no part can be detached except by a mechanic with tools, and where two couplings approaching to couple up are alike, with nothing to take out or put in with either, there can be no such annoyance and delay as where parts are necessarily detachable.

No. 8 needs no comment with respect to any form of coupler.

The same for No. 9, except that with any coupler due caution should be exercised that parts be properly shaped so as not to *work out* of position. A pin is somewhat like a sled stake or the side stake of flat cars, in this—if tapered, it may work up. The science of a sled stake requires that it be a little larger at the point than at the top end of that part where it fits the socket. Trains on long, continuous trips up grades may part by reason of the pin being tapered and working out. A case of this kind came under my personal observation, except that the pin was knocked back into place to prevent parting of train. Pins, latches, catches, etc., used in couplers should be so shaped as to work *from* instead of toward upcoupling.

No. 10 is a point of especial importance. It is well known to those who have observed the action of air brakes on trains with and without free slack, that by far the least jamming and jerking of cars occurs when there is no free slack. The Westinghouse Air Brake Company insists upon Janney couplers, already mentioned above.

This point is well taken by the Westinghouse company for the reason of the impossibility of reducing free slack with safety below about an inch with the link and pin, while for hooks it can be brought down to one-fourth that value, as already pointed out.

In buffer brakes also the free slack must be reduced to the minimum to avoid destructive action upon the buffer brake parts. But as long as these brakes stand the concussion due to free slack, those concussions will be reduced by the presence of the buffer brakes, because, when a car pitches forward against the next, the brake will be set and the concussion at this car checked. Likewise for all the cars with the buffer brakes. A train fully equipped with these brakes will therefore be much relieved from the shocks incident to running over summits and sags with free slack. Buffer brakes must therefore prove a great relief in this matter of concussions, due to the fact that the buffer causes the brake to catch on just at the instant needed, whereas in the air brake the delay between action of brake at the rear of train as compared with the front has the effect to exaggerate the shocks due to free slack.

Besides eliminating free slack from couplers with advantage for all brakes, it is important for buffer brakes that the buffer and draught springs be judiciously arranged for action on the drawbar, in order to secure the maximum of effect with the brakes, such as to enable those brakes to do safe service on steep grades. In the chapter on brakes it is stated that the buffer spring should be capable of about five inches compression, in order that the yielding necessary for working the brake can be had under the initial compression of spring, for which the compressive force will be quite mild; the object being to obtain the full action of brakes with a comparatively light buffer pressure. But the five inches of compressive displacement of drawbar is probably more than railroads will be willing to allow. To reduce the motion and yet secure that necessary for braking under mild pressure, a mild spring may be employed for the 2 to 2½ inches of initial movement for setting the brake, when a second and stiffer spring may come into play. By this arrangement, two or three springs will be needed to each drawbar, but by it we secure the arrangement for highest efficiency of buffer brakes, without an excessive drawbar movement. Three springs are already in use on some drawbars, and with this number the very best conditions for the couplers and also buffer brakes can probably be had, so as to extend the successful operating of trains by buffer brakes to all grades in use.

For No. 11, there can be doubt. Pockets that will carry water, and ice or snow, should be avoided. Openings in cavities in which moving parts work should be kept closed by the moving parts.

That No. 12 should be satisfied is essential, so that there never will be any trouble in moving a car, or coupling it into a train. If hooks are adopted, there must be provision for coupling them with the link and pin.

No. 12 will not be denied. Yard and standing room is too valuable to be taken up by unnecessary space for couplers between cars. An excessive space is dangerous to trainmen, for liability to falling between cars. Out on the line there is room enough, but in going around curves excessive train length is objectionable as giving cause for crowding outward the cars near the engine when the latter is holding back for braking, and in pulling there will be the opposite tendency. In taking sidings and on sidings, undue length of train is very undesirable. All considerations favor shortness of train, so that the drawhead should not be designed for standing far out, with the object of getting in a long mild spring.

The free slack is to be dispensed with to meet this point, and drawheads should be as short as may be.

After thus carefully analyzing the working conditions of couplers, a review of the analyses points in unmistakable terms to the following

CONCLUSIONS.

1. That the avoidance of "free slack" is one of the most important and vital steps to be taken in the coming freight car coupler, both for economy to the road in avoiding wear and tear and for relief from damage of goods in transportation, and that this is only second in importance to the adoption of such devices as shall be automatic, and not hazardous to the lives of trainmen in operating.

2. That the threefold numerous dimensions to be provided for in the link and pin coupler, as compared with hook couplers, and the greater liability to constructive variation in those dimensions, make it absolutely certain that with the link and pin the free slack must unavoidably be very much greater than in hook couplers, leading to disastrous consequences, while with hooks it can be reduced to practically nothing.

3. That with hook couplers the rigging at both ends of a car can be positively identical, with no detachable parts, whereas with the link and pin this is impossible.

4. That close hook couplers can be much lighter than in those where severe concussions occur, as in the link and pin.

5. That close hook couplers serve much more favorably than others in connection with all kinds of brakes.

THE Norfolk, Va., crop of strawberries is larger this year than any since its trucking career began.

THE NEW COURT HOUSE AT NEUILLY-ON-THE-SEINE.

SINCE Neuilly has become enlarged, and has formed into a sort of continuation of the beautiful quarters of Paris, the old township has become insufficient for the needs of an increased population. In 1879, the town council opened a competition for the construction of a court house.

Monsieur André, architect at Lyons, obtained the first prize, but as he could not take charge of the execution of the work, the direction of it was confided to Mr. Dutocq and Mr. Simonet, architects at Neuilly.

The work, which was commenced in June, 1882, was carried on so rapidly that all the offices in the new building were ready for use in the month of September, 1885. The total expense has amounted to about 1,460,000 francs.

The new court house was erected upon Roule Avenue, facing a square of moderate size. The width of the front is forty meters. From the street a large flight of steps leads to the ground floor. The total height from the ground to the top of the cupola tower is forty-two meters. The three arches of the ground floor show by their solid bases that they support strongly the openings between seven columns on the first floor. The Corinthian style predominates in the composition of this story. Above this is an attic surmounted by a clock. The face is surrounded by two standing female figures, representing "Day" and "Night." At the right and at the left are circular pedestals that serve as seats for reclining figures representing the rights and duties of the citizen. On the highest point of the building is an arched attic crowned with two children, who hold up a coat of arms.

The entire statuary of the clock is the work of Mr. Tony Noel. The frieze, of Corinthian style, is composed of garlands and children, cut from the chisel of Mr. Barrias; the reclining figures, "Justice" and "Charity," upon the projecting pieces above the large windows.

The keys on the arches of the ground floor were made by Mr. Gauthier. The coats of arms on the projections are ornamented with children writing or reading the devices. The principal offices occupy the ground floor and the right and left wing of the mezzanine story of the building.

The first story is reserved for offices of state.

THE NEW COURT HOUSE AT NEUILLY ON THE SEINE.

DURABILITY OF RESINOUS WOODS.

By HEINRICH MAYR, Ph.D.

THERE can be no doubt that the resin in the wood derived from the different varieties of conifers, or pine trees, is one of the most important factors which determine its quality, especially its durability and resistance against the influence of weather and the different forms of rot, all of which are now proved to be due to specific fungi. Just at present, timber from American conifers is highly valued in Europe, because of its richness in resin, although the amount of resin in wood is not the sole measure of its quality.

Until now an exact valuation of the importance of pitch in wood was impossible, because the accurate knowledge of the origin and the distribution of the resin, as well as of the arrangement of the organs producing it, was wanting.

At the experimental botanical station at Munich, I have made numerous experiments during a space of many years, and, as the results seem to contain many new points, I thought them worth presenting to the readers of the *Monthly*. In face of the confusion prevailing in the nomenclature, it is necessary to state that the botanical names used are those of Carriere in his "Traité des Coniferes," who separates *Abies* and *Picea* as distinct genera. The distribution of the resiniferous ducts is so characteristic within each of these genera as to serve as typical marks for them.

The species of *Abies* commonly called firs are characterized by the absence of resiniferous ducts within their woods; it is only in rare cases, as in *Abies firma*, or Japan fir, that we meet with them. Sometimes we find a cluster of parallel cells, often quite far apart from each other, filled with resin; these colonies of parallel cells are not to be considered as ducts, but as malformations due to the influence of different causes, like cold and pressure; they are found also in other species of conifers exposed to the same causes, and occasionally attain the size of a man's hand.

The resin is produced only by the parallel cells of the medullary rays in the species *Abies*. Already in the first year's growth the cells are found to contain small drops of resin. The size of these drops increases with the age of the cells, the amount of amylum or starch in them decreasing in proportion.

Resin is composed of substances volatile at 100° C., and others which cannot be distilled without decomposition; the latter form the solid residue when resin or pitch is distilled with water. When the outer or sap-wood (*alburnum*) becomes dry or heart wood (*duramen*), in which form it is that which is known commercially as wood, the cells are found to contain nothing but air, with the resin coating the inside of the cell-walls; fresh pitch, as it oozes from the bark of the European *Abies pectinata*, contains 63 per cent. of solid residue, and this is also the percentage of solid substances in the pitch of the sap-wood of the genus *Abies*, but pitch from the heart or from the dry, inner wood of the tree contains 70 per cent of solid substances.

During the life of a fir tree the cells contain 50 per cent. water, which, when the wood dries, disappears; and the pitch, which at first could not enter into the cell walls, now permeates them, taking the place of the water.

The wood of *Abies pectinata*, which in Europe covers thousands of acres in dense, well-cultivated masses, contains the least resin of any fir cultivated, namely, only $\frac{6}{10}$ per cent. of the perfectly dry sap-wood, while the innermost layers of heart-wood contain $1\frac{1}{4}$ per cent. of pitch; it is therefore of inferior quality as far as richness in resin is concerned; only the very great heights and diameters which trees of this species rapidly attain make them valuable for cultivation.

The genus *Picea* (spruce) has the sap-wood of the same color as the heart-wood; it contains numerous ducts filled with resinous substances. These ducts run in all directions, the horizontal ones being branched off from those running perpendicularly, and communicating with others lying closer to the bark, running vertically. The inside of the ducts is made up of two kinds of cells, the one having thick walls and the same functions as the parenchymatic cells of medullary rays, the others having thin walls. The latter were formerly considered as mere cells of secretion producing resin; but there are many reasons which force me to consider them as merismatic cells, remaining without function sometimes for several years, until the sap-wood containing them becomes dry or heart wood, when they begin their activity. They now increase in size, expanding like vesicles, and totally obstructing the duct, so as to prevent the resin from entering the heart-wood by way of the horizontal duct or sinking from a higher to a lower part of the tree. In the amount of resin contained in the wood, the genus *Picea* ranks second among conifers; the species *Picea excelsa*, common in Europe, contains 2·16 per cent. in the sap-wood and 1·6 per cent. in the heart-wood.

I have found as a result of my investigation that there exists a very important law which will enable a microscopist to tell at a glance the difference between heart-wood and sap-wood: only the heart-wood is fit for building purposes and will stand the influence of weather; the sap-wood will decay rapidly, but is nevertheless used by unscrupulous builders. An examination of the resiniferous ducts will show the difference at a glance. During the process of transition of the sap-wood into heart-wood, *all these resiniferous ducts become closed* by the expansion of the cells surrounding them, a process which can be discerned unmistakably even in the smallest piece of any wood from a conifer; a similar process takes place in the growth of the bark.

Professor Hartig, of Munich, a famous botanist, proved by careful experiments the following law: *The quality of the wood of all trees increases so long as the yearly growth shows a progressive course year after year.* It has been thought until now that the quality of the wood of conifers is the better the closer the annual rings lie; this is but partly true. The older the tree, the closer the annual rings, but the quality of the wood increases only as long as those rings represent an actual progress of growth; when once the annual amount of wood formed begins to diminish year by year, its quality becomes impaired, notwithstanding the rings become closer and narrower.

The amount of resin in the wood follows the same law; if we take, therefore, a splinter or a plug from any tree by means of a hollow auger, we can, by a simple calculation, determine whether the tree is still progressing, or already on the decline in growth, quantity of resin, and value.

In the genus *Pinus*; the resiniferous canals are of different construction, but agree in general arrangement with those of the genus *Picea*; their size is larger and they are inclosed by only thin walled, merismatic cells, which in the course of the transformation of the sap-wood into heart-wood enlarge and close the canals. The heart-wood of the trees of the genus *Pinus* has a light brown color, sometimes a little reddish, the coloring being due to a product of the oxidation of tannin, which is found in the cells and their walls.

The Scotch pine (*Pinus silvestris*), when growing on sandy soil, forms only a very small amount of sap-wood, whereas on gravelly and shallow ground it produces more, but of less valuable quality. Two needles in one sheath characterize this species. The heart-wood of this pine contains 5·7 per cent. of resin, the sap-wood proportionately less.

The sap-wood of this tree is quickly destroyed when the tree is cut; it assumes a dark-blue color and rots, through the agency of the mycelium of a fungus called *Ceratostoma piliferum*.

The white pine, or common American pine (*Pinus strobus*), is now also extensively cultivated in Germany, where some forests can be found of trees about a hundred years old. Its wood has the lowest specific gravity of all coniferous wood. In spring, on account of the thinness of its bark, the tree is quickly warmed through, and the wood cells, formed in the beginning of the spring, are thin walled; at the close of the period of vegetation in summer, the annual rings are finished by a few thick walled narrow cells, thus giving only little thickness to the hard part of the annual layer. In amount of resin this pine stands at the head of all conifers, containing 6·9 per cent. The percentage increases up to the age of one hundred years, and with it the quality of the wood. It is of little value when young and exposed to moisture. *Pinus cembra*, a native of the Alps and Siberia, forms only small, dense rings every year during the short summers of these regions; the wood hence becomes heavier, and, although less resinous, more valuable.—*Popular Sci. Monthly.*

THE TOWN HALL OF FUNFHAUS, NEAR VIENNA.

WHILE the population of Vienna proper increases slowly, the adjoining townships develop all the more rapidly, as they are not restricted by lines of walls or excise of consumption. Some of these townships show a growth almost equal to that of America; and if one should pass by the elegant rows of houses now to be seen in Hernals, Wahring, or Funfhaus, one could hardly believe that only a few centuries ago the houses on these same localities were few and far between, or that the hewer carried on his business where to-day machines roar amid the active development of city life. There is but one thing left that reminds one of the olden time, and that is the order of senate elections. Vienna's townships vote with the country communities; they are villages, and yet there is no other village in the world that could possess such a town hall as that in Funfhaus, the facade of which we present to our readers. It covers a ground area of 2,503 square meters.

It was erected during the years 1882-1885, according to the plans of the architect Gustav Mathies, in Italian Renaissance style. Above the fine foundation that includes the ground floor and mezzanine story are still two more stories.

The center part of the building, with cupola on top, that fronts on Rosina street, is very prettily ornamented. In addition to the projectures standing out on all four corners of the building, the roof here is made in tower shape, and this gives a significance to this part of the town hall, for the sessions are held here.

After ascending a pair of beautiful stairs, one lands in the light large room that takes up two stories. As this is also used for popular assemblies, the gallery that surrounds it at the top of the second story is very suitable.

The rooms for offices have not been neglected, however, on account of the spaciousness of the session room. The whole building is as serviceable as it is handsome, and is an honor to the activity of the community.

The only drawback to a colossal effect is that it is surrounded by narrow side streets namely, Rosina, Gas, New, and Brau streets.

REACTION OF TIN WITH SULPHURIC AND NITRIC ACIDS.

By H. BASSETT.

THE formation of stannic sulphate by the action of sulphuric acid alone on tin requires, as is well known, a high temperature; the addition of a small quantity of nitric acid, which readily supplies the necessary oxygen, greatly facilitates the action, and was long ago applied in the manufacture of the ornamental articles of tin-plate known as "Moirée metallique," the mixed acids dissolving a film of tin from the surface and exposing the crystalline structure of the metal.

A mixture of 1 part sulphuric acid, 2 parts nitric acid, and 3 parts water, all by measure, has a remarkably solvent action on tin in the cold. A solid lump of the metal weighing 10 grms. dissolves completely in a few hours in 50 c. c. of this mixture, the containing vessel being immersed in cold water. Under these circumstances no red fumes are given off, but a steady evolution of nearly pure nitrous oxide goes on the whole time. The resulting solution of stannic sulphate is quite clear unless the temperature has been allowed to rise, in which case it becomes beautifully opalescent, and if heated in the water-oven for an hour it becomes nearly solid and opaque.

On pouring the solution (still containing some nitric acid) into boiling water, the tin is completely precipitated in the form of gelatinous metastannic acid, which after thorough washing with boiling water dries up in the water-oven into semi-transparent lumps.

Attempts to utilize this reaction for the solution and analysis of tin alloys have not proved satisfactory; in presence of some metals a small quantity of tin appears to escape precipitation, while others show more or less tendency to go down with the precipitate.—*Chem. News.*

THE DIFFRACTION SPECTRUM APPLIED TO DEVELOPING ROOM ILLUMINATION PROBLEMS.

PRISMS of different transparent materials, when used to throw spectra upon a screen, give such spectra of varying lengths, according to the dispersive power of the substance employed. For instance: oil of cassia inclosed in a hollow prism will throw a spectrum nearly three times as long as that thrown by a solid prism of flint glass of the same angular dimensions. A hollow glass prism filled with bisulphide of carbon will throw a long and brilliant spectrum; it is, in fact, one which is often used in public lecture experiments. In all these prismatic spectra the red rays are squeezed into a comparatively small space, while the blue, violet, and other rays which act upon ordinary photographic plates are abnormally extended. For this reason, both in photographic and other branches of physical research it is desirable to select some standard spectrum to which to refer all the results of experiments.

The diffraction spectrum answers the purpose, because it is a true spectrum, every section of the length of which is in due relative proportion to the length of the waves of light. The modern idea of the nature of color is that different colors are but sensations due solely to differences in the length of waves of light. The average length of a wave of white light is estimated to be $\frac{1}{50000}$ of an inch; the average red rays are longer, or about $\frac{1}{39000}$ of an inch; and those of violet light are shorter, or about $\frac{1}{57000}$ of an inch.

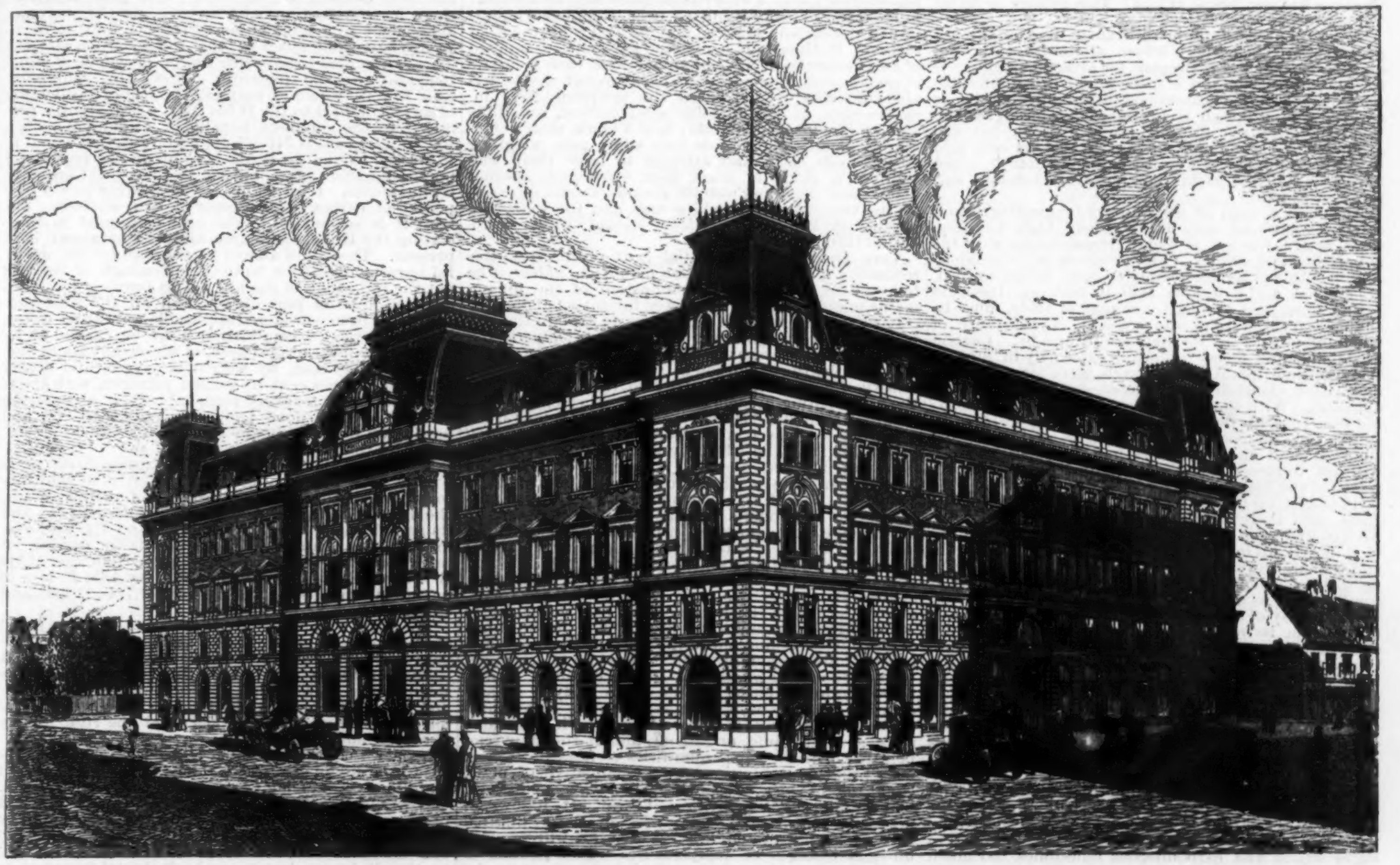
The number of vibrations of a wave of white light per second is estimated at about 500 million millions (500,000,000,000,000); of red light 482 million millions; and of violet light 707 million millions. There are also invisible and longer waves beyond the red noted for their heating power, which Captain Abney has successfully photographed. There are also invisible rays beyond the violet, which make their presence known by their photographic power, by their power of exciting fluorescence in certain bodies, and by their feeble heating power. Helmholtz and others have managed to see most of this ultra-violet spectrum by means of carefully arranged physical appliances and methods of observation. The reason why we cannot see the whole spectrum, and why the visible portion appears to be of unequal luminous intensity, is that our eyes are supposed to be imperfect instruments for the purpose—much more sensitive to the yellow than to other rays, and to much of the spectrum not sensitive at all. There is believed to be no difference between radiant heat and radiant light but that of wave length, and that while the nerves in our hands are sensitive to the waves of the ultra-red end of the spectrum, such as those from iron heated below redness, the same waves are incompetent to excite the nerves of vision.

Thus, according to the views generally held at present by scientific men, the great apparent differences we see in the visible spectrum are due more to physiological conditions inside the human body than to differences in the physical conditions outside thereof.

Recent improvements in the illumination of the developing room give support to the now popular philosophy so far as they go; for, although yellow light makes an enormously large visual impression, it produces no correspondingly striking difference on a gelatino-bromide plate. The photographic action dies away gradually below the blue, and by prolonged exposure the yellow is not found to exert any exceptional influence. This is the foundation of my already published explanation of what seems to be a demonstrated fact—that a half-power pure yellow is safer to work by in the developing room than a full-power red, the intensity of the initial source of light remaining the same; also, that the half-power yellow is much brighter than the full-power red to the human eye, in consequence of the advantage given by the physiological imperfection, assuming a theoretically perfect eye to be one which could see the whole spectrum in the true gradation of its varying wave-lengths. From other points of view such an eye might not be perfect. All objects radiate heat, and if we could see all these radiations we should be without darkness, which, to say the least of it, might interfere with comfortable sleep.

The argument in favor of what appears to be the true theory of developing room illumination is stronger than I at first put it by my reference in the first instance to one of the earliest published curves indicating the luminous intensity of different parts of the visible spectrum. I have since been searching for a more recent curve, and one drawn in relation to the diffraction spectrum, and am indebted to Dr. Huggins for the diagram required. From this it appears that nearly all the luminous intensity of the spectrum is in the yellow, the next largest proportion being in the yellowish-green—a light also safe, when of low intensity, in the developing room. As the red of the spectrum is in greater part between A and C, the small height of the curve at that part of the spectrum indicates the feeble intensity to the human eye of the red light hitherto and at present common in developing rooms.—*W. H. Harrison, in the British Journal of Photography.*

SUBMARINE NAVIGATION.—Some satisfactory trials have recently been made at Liverpool with a new electrical submarine vessel, the invention of Mr. J. F. Waddington, of Birkenhead. The vessel, which is cigar shaped, is 37 feet long and 6 feet in diameter at the center, tapering off to the ends, which are pointed. A conning tower is mounted on the top of the boat, and her depth of immersion below the water surface is regulated by external inclined planes placed one on either side, and controlled from within. She is fitted with a rudder placed aft, and has a self-acting arrangement for preserving her horizontal position. The crew consists of two men, and there is a supply of compressed air for their use when the boat remains submerged for a lengthened period. The motive power is electricity, of which sufficient can be stored on board to propel the boat for ten hours at a speed of about nine miles per hour, either below the water or on its surface. The cells also supply light through glow lamps, and drive a pump for emptying the water ballast tanks, which are filled for submerging the boat. A trial of the vessel in the presence of representatives of the Admiralty is stated to have elicited their approval.



THE TOWN HALL OF FUNFHAUS, NEAR VIENNA.

SIBLEY COLLEGE LECTURES.—VI.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

FIRE.*

By J. C. HOADLEY, of Boston, Mass.

IF any one would accurately gauge his knowledge, and learn how little he knows, let him try to teach something. However much he may have studied a subject as a science, or practiced it as an art, the limitations of his knowledge will press him closely—all the more closely, perhaps, the more he may have learned, unless, indeed, he be content to pour old ignorance from vase to vase, and call it learning.

I feel that I can contribute little toward the elucidation of my subject, beyond some illustrations which may help to impart vividness of conception, and perhaps some clearness of statement and some fullness of practical detail.

My subject is FIRE; not heat alone, but the practical source of useful artificial heat. Combustion is a pretentious word for burning, which adds nothing to the idea except a little clearness when used in a strictly technical sense.

Fire results from the continuous combination of oxygen, in certain definite proportions, with some one or more of two or three substances which, at a certain high temperature, unite eagerly with oxygen, and by this union produce the high temperature necessary to the continuance of the action, and much more, usually, which may be applied to useful purposes. Mere oxidation, as it goes on at low temperatures, cannot usually be called fire, because the heat produced is in such cases dispersed as fast as it is produced; but if such heat be intercepted, so as to accumulate, however slowly, a fire may result at last. This process is called "spontaneous combustion."

Of useful fire-sustaining substances, besides the all-pervading oxygen, there are in all nature only two, namely, carbon and hydrogen; for although sulphur is freely combustible, and is to be found in considerable quantities in the neighborhood of volcanoes, active or extinct, and although it is, unhappily, found in combination with iron in some kinds of coal, yet the products of its combustion are so deleterious, and its heat-producing power is so feeble, that it could hardly be called a useful fuel, however abundant and however cheap.

Carbon is a solid at all ordinary temperatures, and can be volatilized only at extremely high temperatures, or at lower but still high temperatures, with the aid of chemical affinity. The products of its combustion, whether it be completely or only partly burned, are gaseous, and it follows that in burning, the solid carbon must pass through a change of state, must be changed from a solid into a gas, a circumstance of much importance, as we shall see by and by. Carbon exists in three forms, differing extremely in most of their sensible qualities, although (save for accidental impurities) identical in substance—coal, graphite, and diamond. With the first of these alone we have to do; but coal presents degrees of compactness, or solidity, as in wood charcoal, coke, anthracite, and gas-retort charcoal; and the differences in this respect are not without influence on the available heat-producing power of the fuel.

Hydrogen, on the other hand, is the lightest of the gases, and therefore the lightest substance known. No free hydrogen exists in nature, and the vast stores of it locked up in all the waters of the seas, the earth, and the air are unavailable as fuel, being fast bound up with oxygen already, as the result of accomplished combustion, in a union which can be dissolved only by the outlay of as much force, or heat-energy, as can result from its recombustion. Very great quantities of available hydrogen fuel exist, however, in combination with carbon, in the multitudinous forms of the hydrocarbons, in petroleum, and in bituminous coal; combinations more or less stable, requiring an unknown quantity of heat-energy to set them free to enter into new combinations with oxygen, but in all cases yielding much more readily to the solicitations of this ardent suitor than to any efforts to entice them from its embrace.

Carbon is the more important fuel of the two, and therefore the most important fire-sustaining element in nature. Of carbon, too, stores almost inconceivably vast exist in an unavailable condition, disseminated in slates, shales, and carboniferous limestones, too much diffused for use as fuel, but occasionally admitting of profitable distillation. Indeed, so vast is the quantity of carbon contained in the coals and carbonaceous rocks, chiefly in the latter, that the carbon dioxide which would result from its complete combustion, a quantity equal to that from which the solid carbon and the carbon in combination with hydrogen must have been derived, would transcend, as it is estimated, the power of the earth's attraction to hold it as an atmosphere, so that a very large part of it must have been gathered up from interstellar space, as the earth accompanied the sun in its ceaseless march through the fields of the empyrean, much as one gathers soot upon his hat in walking along the streets of Pittsburg.

These two elementary substances, then, are, with unimportant exceptions, the only available sources of artificial heat, the only things with which either a fool or a philosopher can "make a fire." Almost all other elementary substances unite eagerly with oxygen—all burn readily when not already burned—but almost all are found to be firmly united with all the oxygen which they require, burned already, as hydrogen is, to a dead cinder. How comes it, then, that the two eminently combustible substances, the solid carbon, the gaseous hydrogen, in combination with carbon in the liquid (or gaseous) hydrocarbons, are found unconsumed amid the ashes of a burned-up world? The answer is, that the sun's rays, acting on the leaves of plants, have the power of raising the dead carbon from its ashes, from the carbon dioxide resulting from its complete burning up setting the imprisoned arid oxygen free to mingle with its kindred air, and leaving the solid carbon to be assimilated by the plants along with the hydrogen similarly liberated from water. As vegetation has flourished through long periods of geologic time, quickened by the sun, refreshed by the rains, and nourished by the carbon of the air in its aerial form of carbon dioxide, a portion of their more enduring tissue, composed mostly of carbon and the hydrocarbons, has been added, year by year, to the soil, and contributed to the earth's rocky crust, until the quantity so deposited far exceeds all that could ever have existed at any one time in the earth's atmosphere.

The apt conceit of George Stephenson, that the heat of the sun drove his locomotive, is, after all, something deeper than a pretty conceit. It is, indeed, the stored energy of sunshine on that old, old world, liberated in the fires of the locomotive, that urges it on its course.

The burning of hydrogen is a simple matter. A gas already, it unites eagerly, at a temperature a little above incandescence, with eight times its own weight of the gas oxygen, to form nine times its own weight of water. Here is a change of state from two gases to a liquid; but practically the water formed in the fire is discharged, in most instances, as steam, also a gas.

Hydrogen present in coal is always completely burned in any reasonably well managed fire. Indeed, I do not believe that a fire can be so managed as to permit it to escape, unless it be merely distilled away, as in the process of coking, at a temperature too low for ignition.

No trace of it can be found in the gases of combustion escaping with the smoke of a fairly well managed boiler furnace. Even the moisture in the coal, and in the air passing through the coal, if decomposed into oxygen and hydrogen in the fire, is reformed later with neither gain nor loss of heat.

The combustion of carbon, on the other hand, is far from simple. A solid is first to be converted into a gas, and then to be united with 2⅔ times its own weight of oxygen, to form 3⅔ times it own weight of gaseous carbon dioxide (CO_2). Two separate gases *may* be formed; but carbon dioxide, resulting from complete combustion of the carbon, must be first formed from the solid carbon. If, then, this compound substance, composed of two molecules of oxygen united with each molecule of carbon, still hot, is made to pass through a considerable thickness of coal below the temperature of incandescence, it will dissolve solid carbon, and take along molecule for molecule; as if a black man weighing 100 pounds should join two white men weighing 133⅓ pounds each, and attempt to force their way through a cloud of black men, whereupon another black man, weighing also 100 pounds, should seize one of the two 133⅓ pound white men, and the four—two white men and two black men—should press on together through the crowd.

Very great loss of potential heat results from this secondary formation of carbon monoxide, unless it be followed by subsequent recombustion of the inflammable monoxide and the renewed formation of dioxide.

Pardon a few words of digression, to explain the difference between *quantity of heat* and *temperature*. Temperatures are measured by the thermometer, which indicates, by the expansion of some substance, the intensity of heat energy imparted to that substance by the heat existing in some other body of which the temperature is sought. Mercury, alcohol, and common air (completely deprived of moisture) are examples of such substances; and the effect by which intensity of heat is measured is the observed difference of expansion between any one of these substances and the glass bulb and tube of the instrument. The interval between two fixed points on the tube corresponding to two assumed temperatures, usually those at which ice melts and at which water boils under prescribed conditions, is divided into some number of parts of equal volume, equal also in lengths, if the tube is of uniform caliber—80° in the Reaumur scale, 100° in the Centigrade, and 180° in the Fahrenheit. The thermometer is one of the most important instruments in the hands of the physicist (and one of the least satisfactory when exact results are sought); but it gives no information, by itself, as to the *quantity* of heat contained in any body whatever, either in the entire body or in any definite quantity of it, such as a pound. Substances of the same kind, of uniform quality, in the same state, as solid, liquid, or gaseous, and at the same temperature, contain equal quantities of heat in units of mass; that is, taking weight as indicative of mass, equal weights of a substance, under such conditions, will contain equal quantities of heat. It follows of necessity that equal quantities of heat diffused throughout unequal masses, or weights, will produce unequal changes of temperature. Two pounds of water, for instance, will be raised in temperature, by the addition of a given quantity of heat, only half as much as one pound would be.

Substances also differ very greatly in the effect produced upon their temperature by a given quantity of heat. Water is less affected than any known substance except certain mixtures of alcohol and water, which require a little more heat added or taken away, to affect them 1°, than water does.

This quality gives rise to what is called the specific heat of substances, that is, the specific quantity of heat required by unit of mass to affect them by unit of temperature, compared with some standard. The standard universally adopted is the unit of mass (or weight) of water between the melting point of ice and 1° above that point. For, in common with all other liquid and all solid substances, water varies in specific heat at various temperatures. Almost universally the specific heat increases as the temperature rises. In the case of water, however, it decreases slightly from the melting point of ice up to about 30° C. = 86° F., above which point it increases slowly.*

Now it is as necessary to have a standard unit for the quantity of heat contained in bodies as a standard of length for their dimensions or standard of weight for their quantity of matter.

The unit of heat chosen is the quantity of heat required to affect unit of mass of ice-cold water by unit of temperature; in English measures, to raise 1 pound of ice-cold water 1° F., that is from 32° F. to 33° F. This unit is a perfectly fixed and definite quantity, just as one revolution of a wheel is a fixed and definite quantity of angular motion.

Having now got clearly in our minds what quantities of heat mean, and what the British unit of heat, or, more concisely, the British thermal unit, is, we can go on to examine the result of burning in our fire a pound of carbon, a pound of hydrogen, and a pound of coal, as to its two combustible elements, carbon and hydrogen.

A pound of carbon burned to carbon dioxide (CO_2) occupies no greater volume, at the same temperature and pressure, than the oxygen alone occupied before the union, although the carbon is now in the gaseous form.

There has therefore been a condensation of the gaseous carbon and the oxygen, in uniting chemically two molecules of oxygen with one molecule of carbon; and the result is the production of heat. The experiments of Fabre and Silberman, which are generally accepted, give as the quantity of heat produced by the complete combustion of one pound of carbon in the form of wood charcoal with 2⅔ pounds of pure oxygen, 14,544 B. t. u., enough to make 96 gallons of ice-cold water boiling hot.

If this carbon dioxide now passes, while hot, through a body of coal below red heat, and takes up, dissolves, another molecule of carbon for each one already burned, that is another pound of carbon, no more heat is produced, but on the contrary a large part of the heat originally produced is destroyed, and the quantity left, apparently produced by the partial burning of *two* pounds of carbon to carbon monoxide (CO), is only 8,902 B. t. u., twice as much carbon, and only 61 *per cent.* of the heat.

For each 1 pound of carbon, 10,093 B. t. u. of the 14,544 have disappeared, and only 4,451 remain—a net loss of almost 70 *per cent.*

This seems anomalous; one equivalent of oxygen, by its union with carbon in CO, appears to have produced only 4,451 B. t. u., while the addition of another equivalent adds 10,093--more than 2¼ times (2·27) as much. The explanation is not far to seek. Solid carbon had to be gasified, and 5,642 B. t. u. (10,093 — 4,451 = 5,642) had to be devoted to that work. The gaseous carbon then, in combination with oxygen, as CO, becomes denser, not so much denser as the CO_2, but so as to occupy the same space as the *solid* carbon and the oxygen occupied before their union, of course at equal temperatures and pressures. Now, this difference, 5,642 B. t. u., which we may call the heat of gasification of carbon, added to the 14,544 B. t. u. apparently produced by the complete burning of 1 pound of carbon to CO_2, gives us 14,544 + 5,642 = 20,186 B. t. u., equal to 10,093 × 2, as the probable heat-producing power of 1 pound of *carbon gas*, could such a thing be at ordinary temperatures. It probably *is* the heating power of 1 pound of carbon in the vapor of hydrocarbons; but here it is so masked by the heat consumed in dissociating the H and C that we know little about it at present. The loss of almost 70 *per cent.* by the wasteful burning of carbon to CO, bad enough of itself, is not the full extent of the loss. The burning has been assumed to be in pure oxygen, and all the heat produced has been considered applicable to heating water. In actual practice, combustion must be carried on by the oxygen of the atmosphere, of which only about one-fifth, or 23 per cent. by weight, is oxygen and nearly four-fifths, 77 per cent. by weight, nitrogen, with about 24 pounds of air for every pound of carbon, air entering at ordinary out door temperatures, say 60° F., and passing off to the chimney rarely below 360° F., or 300° F. hotter than it entered.

Now, since the specific heat of atmospheric air is 0·238 (a little less than ¼ that of water), if we multiply together, continuously, the number of pounds of air, the number of degrees added to its temperature, and its specific heat, thus: $24 \times 300 \times 0{\cdot}238 = 1{,}714$, we have, in B. t. u., a quantity of heat inevitably carried off (with ordinary arrangements), alike from the 14,544 B. t. u. of full combustion and from the 4,451 B. t. u. of imperfect combustion; and 14,544—1,714 = 12,830, and 4,451—1,714 = 2,737.

The latter number is only 21 per cent. (21·33 per cent.) of the former, and the loss is about 79 per cent. (78·67 per cent.) of the available heat of full combustion. It is further to be remembered that all losses from the steam boiler, by radiation, conduction, and convection, are just as large at equal temperatures when CO is formed as when CO_2 is formed; and the *ratio* of loss of course much greater.

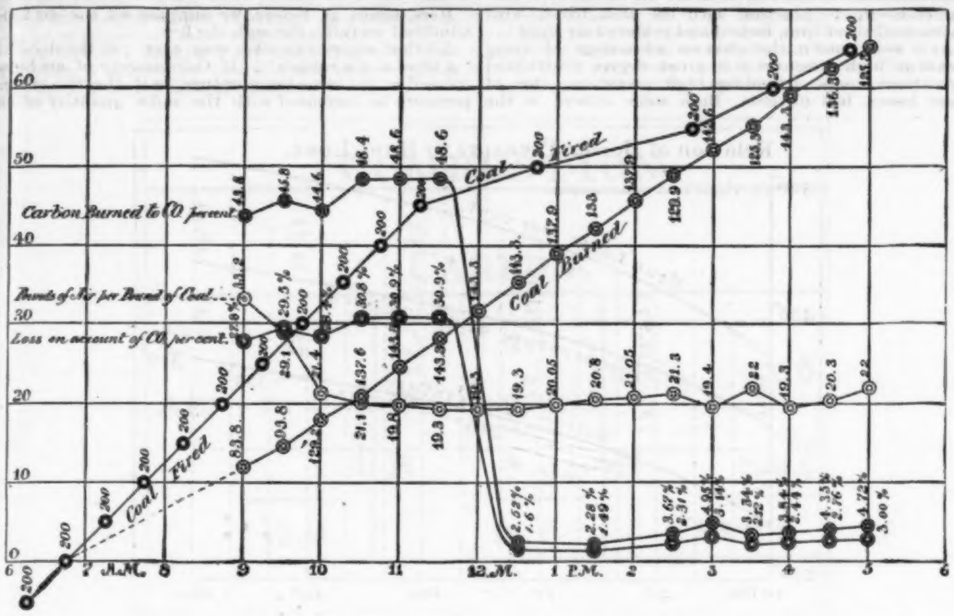
In fact, for every pound of carbon permitted to pass off to the chimney as CO, not more than from ¼ to ⅕ of its full heat-producing power is available. Fortunately, however, this danger, which looks so formidable, and has been, time out of mind, one of the stalking horses of the boiler improver, is not so bad as it looks. Carbon monoxide (CO) can be made in large quantities, as we all know; but to make it special furnaces are required, very deep and narrow, with slow combustion at the bottom and black coal atop. In good ordinary steam boiler practice it is rarely produced in more than minute traces during the daytime, when dampers are open, and need never be produced. The diagram here exhibited shows, graphically, the result of persistent, systematic effort to produce CO on a grate of 25 square feet, under an externally fired return tubular boiler 60 inches in diameter, with 65 flues 20 feet long. At regular intervals of half an hour 200 lb. of anthracite coal, egg size, was thrown on the fire—400 pounds per hour, 16 pounds per square foot per hour—with a draught capable of burning to CO_2 only about seven-tenths of that quantity. This was kept up for about five hours, until the coal was heaped up closely around the shell of the boiler.

An hour and a half was then allowed to pass before firing two hundred pounds more coal, and then two hours, followed by intervals of one hour. At nine o'clock A. M., and half-hourly thereafter until half-past eleven, then hourly until half-past ten, then half-hourly until five P. M., samples of gases from the chimney were taken and analyzed. The quantity of air per pound of carbon is pretty regular—about twenty pounds after ten o'clock. The proportion of the carbon burned which was wastefully carried off as CO is pretty uniform from nine o'clock until half-past eleven, running from 43·8 per cent. to 48·6 per cent.—averaging 46·6 per cent.

This excessive quantity was formed during the period of hard firing. An hour later, at twelve-thirty, the fire having had an hour and a quarter of respite, and having become ignited throughout, although still very thick, the proportion of carbon carried off as CO has fallen to 2·52 per cent., and remains low, averaging 3·7 per cent. to the end. The apparatus afforded the means of computing the rate of coal consumption, and the several points so determined every half hour, from nine o'clock A. M. until five o'clock P. M., fall into a

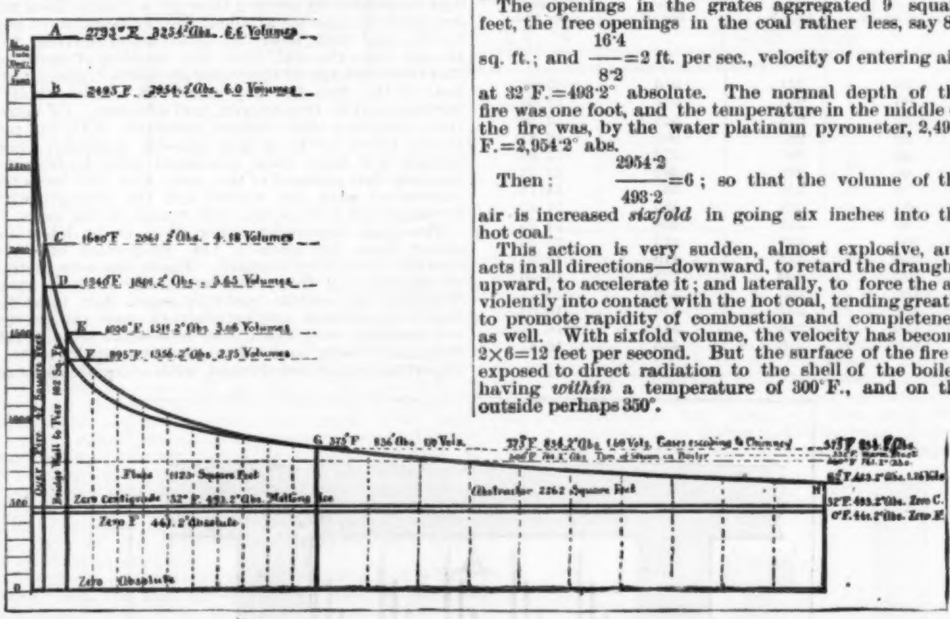
* A very brief abstract of this lecture was published in our issue of Jan. 30. We are now permitted to present the whole of this valuable discussion.—ED. SCI. AM.

* Prof. Henry A. Rowland, Mech. Eq. of Heat, p. 198.



line very nearly straight, showing that with uniform consumption of coal, the heat produced varied extremely. This diagram is very instructive and extremely interesting; but its greatest lesson is that, with reasonable care and skill in firing, no formidable loss can arise from wasteful formation and release to the chimney of carbon monoxide (CO).

No formidable loss during the day; but banked fires waste fearfully unless the dampers are absolutely tight, much the larger part of the carbon consumed while the fires are banked going off as CO wastefully. Anthracite suffers greater loss from this cause than bitumin-



ous coal. The latter cakes over and forms a cover, beneath which the escaping gases are kept hot until they reach an orifice resembling a gas-burner, whence they issue and burn to CO_2. On this account it is a good plan to use bituminous coal for banking anthracite fires.

After all, dampers cannot be too carefully fitted nor too jealously watched, to keep them as tight as possible when closed.

I have said that every pound of carbon will require for its combustion to CO_2 about twenty-four pounds of air. This is about double the quantity which would be required if it were possible to get all the oxygen out of the air; but that is not possible.

A tallow candle will go out, it is said (by Angus Smith, "Air and Rain"), in a closed chamber in which the proportion of oxygen, normally 21 per cent., is reduced to 17 per cent.; and even if a cup of melted tallow be kept up around the wick by heat introduced from without, the candle will still cease to burn long before one-half the oxygen is exhausted. On the other hand, in pure oxygen, iron burns with ravenous avidity, more freely than cotton in the common air. The presence of about four molecules of nitrogen for each molecule of oxygen suffices to render iron incombustible under ordinary conditions, and, in like manner, the presence of say eight molecules of nitrogen for each molecule of oxygen seems to render carbon incombustible under the conditions obtaining in the furnaces of steam boilers.

Let us examine, *first*, these conditions, and *second*, the physical causes of the impediment to combustion offered by the presence of larger relative quantities of nitrogen. To give definiteness to our ideas, we will consider the first question, as the conditions present themselves in a specific case—that of the boiler already mentioned, at the Pacific Mills. According to our diagram, we burned 3,000 pounds of anthracite on twenty-five square feet of grates in eleven hours—nearly eleven pounds per hour on every square foot of fire grate area. But that was too rapid for the draught, and much carbon was carried off as CO. The proper rate for the draught was nine pounds per square foot per hour. The coal contained about 82 per cent. of carbon and about 2 per cent. of hydrogen, and required, therefore, about twenty-one pounds of air to the pound of *coal;*

$$\left((24\times0{\cdot}82)+\left(\frac{24\times8}{2\frac{1}{4}}\times0{\cdot}02\right)=21{\cdot}12\right)$$

The mean quantity for the whole eight hours observed—nine A. M. to five P. M.—was 21·3. The quantity of air, then, was 25×9×21=4,725 pounds per hour.

We may take its volume at 12·5 cubic feet to the pound, and 4,725×12·5=59,062 will be the number of cubic feet per hour=984 c. ft. per minute=16·4 c. ft. per second.

The openings in the grates aggregated 9 square feet, the free openings in the coal rather less, say 8·2 sq. ft.; and $\frac{16{\cdot}4}{8{\cdot}2}$=2 ft. per sec., velocity of entering air, at 32°F.=493·2° absolute. The normal depth of the fire was one foot, and the temperature in the middle of the fire was, by the water platinum pyrometer, 2,493° F.=2,954·2° abs.

Then: $\frac{2954{\cdot}2}{493{\cdot}2}$=6; so that the volume of the air is increased *sixfold* in going six inches into the hot coal.

This action is very sudden, almost explosive, and acts in all directions—downward, to retard the draught; upward, to accelerate it; and laterally, to force the air violently into contact with the hot coal, tending greatly to promote rapidity of combustion and completeness as well. With sixfold volume, the velocity has become 2×6=12 feet per second. But the surface of the fire is exposed to direct radiation to the shell of the boiler, having *within* a temperature of 300°F., and on the outside perhaps 350°.

Forty *per cent.* of all the heat generated by the fire escapes by direct radiation to the boiler from the incandescent solid fuel, and the temperature of the gases at the bridge-wall (corresponding substantially to that of the surface of the coal), will be found to be 1,340°F.=1,801·2° abs. And $\frac{1801{\cdot}2}{493{\cdot}2}$=3·65 times the original volume. Then, a mean of volumes=$\frac{1+6+6+3{\cdot}65}{4}$=4·16 times the original volume, and 4·16×2=8·32 ft. per sec. equal the mean velocity. The distance being 1 foot, the time will be $\frac{1}{8{\cdot}32}$ sec.=0·12 sec.

At the bridge wall, the area for the passage of the gases is 7·6 square feet, and distance from the front end of the grates to the further side of the bridge wall is 6 feet, and from the middle of the grates, 3·5 ft. The velocity will therefore be $\frac{8{\cdot}32\times8{\cdot}2}{7{\cdot}6}$=8·98 ft. per sec. and the time $\frac{3{\cdot}5}{8{\cdot}98}$=0·39 sec. At the pier, before entering the flues, the temperature of the gases will have fallen to 895° F.=1,356·2° absolute, and $\frac{1356{\cdot}2}{493{\cdot}2}$=2·75 times the original volume, and $\frac{2{\cdot}75\times3{\cdot}65}{2}$=3·2 will be the mean relative volume, and 2×3·2=6·4 ft. the velocity per sec. for the same area.

The area of cross section at this place is 12 square feet; and the velocity will therefore be $\frac{8{\cdot}2\times6{\cdot}4}{12}$=4·37 ft. per second. The time will be, for 13 feet at 4·37 ft. per second: $\frac{13}{4{\cdot}37}$=2·98 seconds.

At the smoke-box, the temperature will have fallen to 373° F.=834·2 abs., and $\frac{834{\cdot}2}{493{\cdot}2}$=1·69 and 1·69×2=3·38 ft. per sec. velocity in same area of cross sec., and $\frac{5{\cdot}50+3{\cdot}38}{2}$=4·44 feet per sec. will be the mean velocity for original area=8·2 sq. ft. The aggregate area of the 65 flues, 4½ inches inside diameter, is 6·4 sq. ft. The length of the flues is 20 feet.

Then the mean velocity will be $\frac{4{\cdot}44\times8{\cdot}2}{6{\cdot}4}$=5·60 ft. per second; and the time $\frac{20}{5{\cdot}69}$=3·50 seconds.

The whole time, from the entrance of air at the fire grate to the discharge of the gases of combustion at the smoke box, will be:

TABLE I.

Combustion at the rate of 9 lb. of coal per square foot of fire grate area per hour. 100 per cent. surplus air.	Distance. Feet.	Volume. Cubic feet.	Velocity. Feet per sec.	Time. Seconds.
Through the fire:				
Initial		16·4	2·0	
Maximum		98·4	12·0	
Final		59·8	7·30	
Mean	1·0	68·2	8·32	0·12
To bridge wall	3·5	59·8	8·76	0·40
Bridge wall to pier	13·0	52·5	4·37	2·98
Through flues	20·0	36·4	5·69	3·50
Final		27·7	4·33	
Total	37·5		5·36	7·00

We find by examining this table that in burning anthracite in a fire one foot thick, at the rate of nine pounds of coal per sq. foot of grate per hour, air passes through the spaces in the grate-bars and enters the coal at a velocity of about two feet per second; is heated up to about 2,500° F., and expanded sixfold, in about $\frac{1}{16}$ second; passes through the fire and combines with all the carbon (and hydrogen too) which it is ever to get, in about ⅛ second; flows on, with gradually diminishing volume, as its temperature is reduced, and at velocities varying slightly with variations in the size of passages and in the volume of gases, but on the whole with diminishing velocity, averaging over five feet per second, and finally passes away from the boiler seven seconds after entering the fire. On entering, every molecule of oxygen was guarded by four molecules of nitrogen; on emerging from the upper surface of the fire, half the oxygen molecules have escaped from their guards, and every two of them have carried off captive a molecule of carbon. But the guard is now doubled over the remaining oxygen molecules; there are now 7 or 8 to 1, and the physical, mechanical, obstruction these surrounded molecules encounter in moving toward carbon molecules may be readily understood. Suppose you have a stream of red and white beans, in the proportion of four red ones to one white one, running along at the rate of eight or nine feet per second, and you had ⅛ of a second only in which to pick out white beans as the mixed stream sped by, it will be seen readily that the task grows harder as the proportion of the white beans to the red ones grows smaller.

Or, suppose that instead of beans we have a stream of iron and brass beads, all of the same form and of about the same size, flowing past a set of magnets occupying one foot in length of the trough, so that the mixed stream, four brass beads to one iron one, flowing at the rate of eight feet per second, is exposed during ⅛ of a second to the action of the magnets. It is plain that the iron beads will grow more and more difficult of access as they grow relatively less numerous, and the guarding, protecting, or obstructing brass beads grow more and more preponderating. It is common to regard oxygen as the life-sustaining element, and to consider nitrogen as the negative of life. No form of life, such as we know life to be, can be supported, it is true, without the presence and active agency of oxygen; but after all, the great, calm, mild, passionless atmosphere of nitrogen in which all life is swathed is the sole protection of every form of life from instant destruction. In an atmosphere of pure oxygen, all animal life would expire in a few delirious gasps, perhaps of delirious ecstasy, much sooner than "a fish out of water." All vegetation would be shriveled and consumed, and the earth would be reduced to a mass of volcanic ashes.

We must be content, I believe, with about one-half of the oxygen contained in atmospheric air, and try to find ways, not too costly nor too troublesome, for reducing to a minimum the loss of heat caused by this great mass of air—about twenty times as great as the weight of coal burned.

The temperatures on the diagram we have just considered were derived from pyrometric observation, connected so far as necessary in order to represent the two sets of observations on one diagram; that is, all brought to the common basis of 32° F. for the air supply with cold blast. The quantity of air per pound of coal was known in one case and assumed in the other case to be 20·36 pounds; and the specific heat of the gases of combustion being 0·238, the heat of the fire should be:

$$\frac{14544\times0{\cdot}82}{20{\cdot}36\times0{\cdot}238}=\frac{11926}{4{\cdot}8456}=\ldots\ldots\ldots\ldots 2461^\circ\text{ F.}$$

Above the entering air.................. 32° F.

Temperature of fire.................. 2493° F.

Agreeing with the mean of many observations. The carbon was equal to 82 per cent. of the coal.

With the warm blast, the air entered the fire 300° hotter, namely, at 333° F., and the result was 300° higher temperature in the fire, with the same

Increment.................. 2461°
T. of entering air.................. 333°

Temperature of fire.................. 2793°

The quantity of air, 20·36 lb. per lb. of *coal*, corresponds to 24·83 lb. per lb. of *carbon*, thus: $\frac{20{\cdot}36}{0{\cdot}82} = 24{\cdot}83$—not far from 100 per cent. surplus. Adding to the 20·36 pounds the 0·82 pound of carbon, we have 21·18 pounds of *dry* flue gases produced in burning each pound of coal. Its specific heat being 0·238, invariable at all temperatures, we have,

$$21{\cdot}18 \times 0{\cdot}238 = 5{\cdot}04084 \text{ B. t. u.}$$

carried off from the fire to the chimney by the gases for each degree F. by which they go out warmer than the air came in. The following table shows the loss, in B. t. u. and per cent., for 100 per cent. surplus air and for 60° F. temperature of external air, for each 10° F.

TABLE II.

Heat carried away by flue gases, with 100 per cent. surplus air. Temperature of air take at 60° F.

Temperature of flue gases. Deg. F.	Heat lost in degrees. Deg. F.	Heat lost in British thermal units.	Ratio of heat lost to total per cent.
60	0		
70	10	50 8	0·43
80	20	101 7	0·85
90	30	152·5	1·28
100	40	203·4	1·71
110	50	254·2	2·13
120	60	305·0	2·56
130	70	355·9	2·99
140	80	406·7	3·41
150	90	457·5	3·84
160	100	508·4	4 26
170	110	559·2	4 68
180	120	610·0	5·11
190	130	660·9	5·54
200	140	711·7	5·97
210	150	762·5	6·39
220	160	813·4	6·82
230	170	864·2	7·25
240	180	915·1	7·67
250	190	965·9	8·10
260	200	1016·7	8·53
270	210	1067·6	8·95
280	220	1118·4	9·38
290	230	1169·3	9·80
300	240	1220·1	10·23
310	250	1270·9	10·66
320	260	1321·8	11·08
330	270	1372·6	11·51
340	280	1423·4	11·93
350	290	1474·3	12·36
360	300	1525·1	12·79
370	310	1575·9	13·21
380	320	1626·8	13·64
390	330	1677·6	14·07
400	340	1728·5	14·49
410	350	1779·3	14·92
420	360	1830·1	15·35
430	370	1881·0	15·77
440	380	1931·8	16·20
450	390	1982·6	16·62
460	400	2033·5	17·05
470	410	2084·3	17 48
480	420	2131·2	17·90
490	430	2186·0	18·33
500	440	2236·8	18·76
510	450	2288·0	19·18
520	460	2338·0	19·61
530	470	2389·0	20·03
540	480	2440·0	20·46
550	490	2491·0	20 89
560	500	2542·0	21·31
570	510	2593·0	21·74
580	520	2644·0	22·16
590	530	2694·0	22·60
600	540	2745·0	23·02
610	550	2796·0	23·45
620	560	2847·9	23·87
630	570	2898·0	24·30
640	580	2949 0	24·72
650	590	2999·0	25·15
660	600	3050·0	25·58
670	610	3101·0	26·00
680	620	3152·0	26·43
690	630	3203·0	26·85
700	640	3253·0	27·28

The loss from this cause ought to be kept down, as it may be, to 15 per cent., and two-thirds of this may be saved by the Green's economizer, or by an abstractor for cooling the gases by imparting a great portion of their heat to the air supplying the furnace.

It is not practicable to reduce the temperature of the escaping gases within less than about 75° of that of the steam in the boiler. If the steam pressure fluctuates sensibly, the temperature of the gases in the smoke box will rise and fall with it. The two sets of observations, taken quarter hourly, and plotted together on a suitable scale, will show a curious resemblance, only modified by a marked fall of temperature in the smoke box whenever the fire door is opened. And this leads me to remark that a deceptive appearance of economy, in reality accompanied by great waste, often arises from leaks in the brickwork around a boiler and about the arch front. All the air a fire needs or can turn to good account can be introduced through the fire itself, and all air should be jealously excluded at every other point. Admitted, intentionally or not, above the fire, it checks the draught *through* the fire, cools the gases, retards the transmission of heat, and finally carries off heat in disguise, the low temperature due to this surreptitious air throwing attendants and observers off their guard, and may easily double the legitimate loss at the chimney. Ordinary brickwork is very porous. The leakage through a brick wall 8 inches thick, free from visible cracks, and apparently sound, will surprise him who tries it for the first time. A candle may be blown out by the breath through a sound 12 inch wall, by expanding the pressure over 2 square feet, and concentrating the air which filters through the wall from an equal area on the other side through a funnel. Cracks, too, are caused by expansion, and are hard to contend with. I believe that it would be worth while to incase the whole boiler setting—bottom, sides, top, and ends—up to junction with the arch front, with galvanized sheet iron, locked and soldered air tight.

As is well known, the obvious advantage of using steam at high pressures is in great degree neutralized by various losses attending high pressures. One of these losses, less obvious than some others, is the higher temperature at which the gaseous products of combustion must pass away from the hotter boiler. The following table shows how this loss increases, from 10 pounds up to 160 pounds per square inch above the atmosphere, rapidly at first, and more slowly at higher pressures.

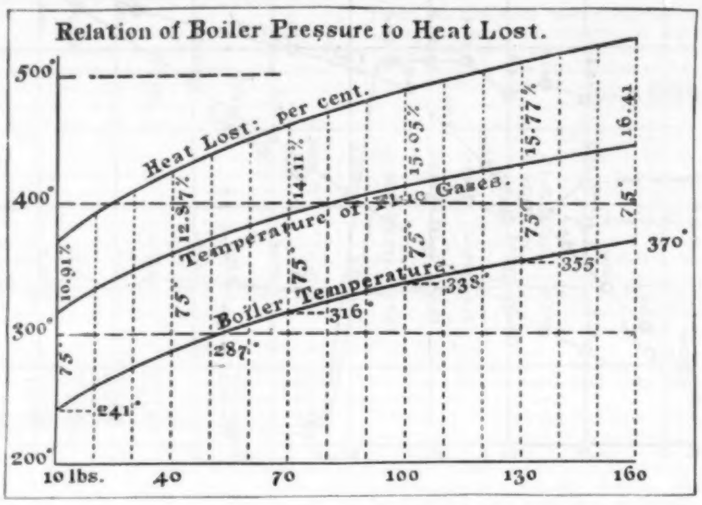


TABLE III.

Effect of boiler pressure upon the quantity of heat carried away by flue gases; 100 per cent. surplus air; temperature 75° F. above that of the steam and water.

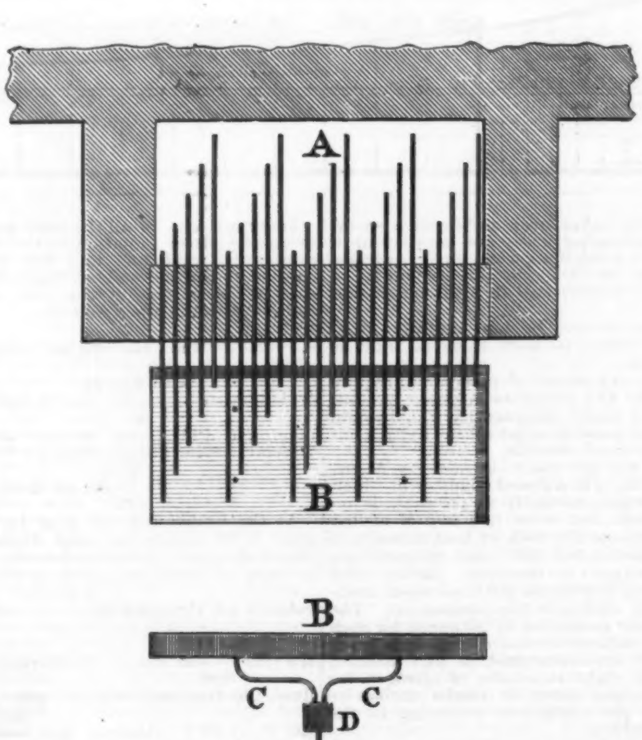
Steam gauge pressure, lb. per sq. in. above atm.	Temperature of steam. Deg. F.	Temperature of gases. Deg. F.	Ratio of heat loss to total per cent.
10	241	316	10·91
20	253	334	11·68
30	274	349	12·32
40	287	362	12·87
50	297	372	13·30
60	307	382	13·73
70	316	391	14·11
80	324	399	14·45
90	331	406	14·75
100	338	413	15·05
110	344	419	15·31
120	350	425	15·56
130	355	430	15·77
140	361	436	16·03
150	366	441	16·24
160	370	445	16·41

Here, again, as before, we suppose all the air to be admitted usefully, through the fire.

All that enters *any other way*, even "at the door," is "a thief and a robber"! If the quantity of air be increased at the same temperature, or if the rise of temperature be increased with the same quantity of air, the loss will be equally augmented, and in direct proportion to the increase of temperature or quantity.

The two things about a fire most important to be known are *first*, the temperature of the gaseous products of combustion at their escape from the heating surfaces of the boiler; and *second*, their composition, first of all having made sure that nearly all the air has passed through the fire. The quantity and composition of the coal consumed in any given period of time, as a day or a week, being known by weight and analysis, the composition of the gases during the same period will determine the quantity of air admitted for each pound of carbon and for each pound of coal. Being first desiccated by passing through a U-tube filled with dry calcium chloride at about the temperature of melting ice, and thus deprived of all water derived from the air, from the coal, from the burning of hydrogen, and from leakage of the boiler at joints exposed to the heat of the fire, the dry gases will consist wholly of carbon dioxide, free oxygen, and nitrogen. Of course, there *may* be a little carbon monoxide (CO), but practically there rarely is any sensible quantity. Some oxygen will have been combined with hydrogen in burning that element of the coal, and will have been eliminated with the water; and the nitrogen which accompanied such oxygen will remain in the gases.

The single important thing, then, to be determined about these dry gases is the proportion of carbon dioxide (CO_2) they contain. There are two methods of determining this: the volumetric method, by the Winckler apparatus—not very exact, but in skillful hands expeditious and satisfactory—and the gravimetric method, very exact, but somewhat tedious, laborious, and costly, and not to be attempted but by an expert and practiced chemist, with adequate assistance



Sampler and Mixer for

FLUE GASES.

Scale ¼ full size. Nov. 24. 1884. J. E. Hoadley, Boston, M.

and apparatus. When well carried out, this method gives the weight of coal consumed as accurately as it can be obtained on scales at the fire-door.

But, however analyzed, the first thing to be done is to obtain a sample for analysis, and this, simple as it may seem, is a very difficult matter.

COMBUSTION.

CARBON.

C	1.	C	1.	CO_2	3.66
Air	11.6	O	2.66		
		N	8.94	N	8.94
	12.6		12.6		12.6

HYDROGEN.

H	1.	H	1.	H_2O	9.
Air	34.8	O	8		
		N	26.8	N	26.8
	35.8		35.8		35.8

Two or more samples taken at different times, no more than a few minutes apart, from the same place in the same flue, or at the same instant from different parts of the same flue only a few feet, nay, a few inches apart, will be found to differ widely in composition.

Even in temperature, very wide variations, as much as 60° F., will be found simultaneously in a small flue. It is therefore necessary to obtain samples from all parts of a cross section of a flue, in order to ascertain by analysis the real composition of the gases. The "sampler and mixer" shown in the diagram here exhibited has been found to accomplish its purpose very well. It is a simple but an ingenious device of Mr. Frederick H. Prentiss, an accomplished chemist and a mechanical engineer full of resources to meet new cases as they arise in practice. A is the cross section of a vertical flue, 10" × 36", the gases descending in rear of a boiler to an underground flue.

B is the horizontal section of a shallow box, a little larger than the flue, about 17" × 37" and 2½" deep, of galvanized sheet iron, air-tight. Opposite this box, another similar box, of the same length and thickness, but only 8" wide, is let into the brick wall of the flue, occupying the space of one course of brick. Twenty-five tubes of ¼ in. gas pipe, about 27" long, all of equal size and length, and similarly finished at the ends, are so distributed in sets of five that their open ends in the flue, A, command equal areas of the cross section—about 23 sq. in. each. These tubes are soldered into the narrow box in the brick wall, and their outer open ends are inside of the larger box. Four tubes, seen as dots in the box, B, and shown at C C in the elevation below the section, connect the box, B, with the mixing box, D, about 3 in. cube, also of galvanized sheet iron; and an outlet pipe, E, extending downward from the bottom of the mixing box, is to be connected by a flexible tube with an aspirator. By this means gases from all parts of the flue are made to flow into the mixing box; and as the draught is equal on all the pipes, and the resistance equal in them all, it is to be presumed that the flow will be equal in them all. A test of the completeness of the mixture is afforded by putting two sets of this apparatus, one above the other, about 1 foot apart, in the same flue, taking care to reverse the position of the tube-ends, a long end over a short end, etc. Samples taken from the two boxes will be found to agree in composition.

It is often desirable to take samples of flue gases for analysis at times when it is impracticable or inconvenient to analyze them. Samples may be stored over glycerine for any length of time. It is not safe to store them over water, as water absorbs CO_2 (carbon dioxide) in considerable quantity. Glass bottles may be used, but cans of galvanized sheet iron are preferable. Being filled with glycerine, and connected at the top with a pipe conveying gases from the mixer to the aspirator, a flow of glycerine out of the can will be attended by an equal flow of the mixed gases into it; and this flow can be regulated at pleasure, so as to make the contents of the can represent any period of time from a few minutes to half a day, or a whole day, or a whole night.

For taking temperatures of flue gases, an air thermometer is almost indispensable. A very convenient and simple form, by expansion of dry air with constant volume, devised, I believe, by Regnault, has been constructed by Mr. Prentiss, and can be made anywhere at any time for $3 to $5—requiring, however, the aid of an expert glass blower. A description of it would be too long, and would be out of place here.

I have said very little about the combustion of hydrogen. The chart, or table 1 now show you exhibits the combinations and mixtures which take place when hydrogen is burned in atmospheric air. If all the oxygen of the air could be brought into combination with hydrogen, 34·8 lb. of air (about 418 cubic feet) would suffice to burn 1 pound of hydrogen, and thereby to produce 9 pounds of water, of course in the form of vapor, accompanied by 26·8 pounds of nitrogen. But it is to be presumed, in this case also, that great excess of air is necessary. The heat resulting from this combustion is very great—no less than 62,032 B. t. u., according to Fabre and Silberman; but the great mass of nitrogen and (probably) of accompanying surplus air, the heat of vaporization of the resulting water (965·7 B. t. u. per pound), and the high specific heat of steam—0·48, double that of carbon dioxide (CO_2)—considerably reduce the available heat. Still, it is always necessary to take account of it, even in burning anthracite, which usually contains rather less than 2 per cent. of this element.

These details are dull and prosy; it is impossible to infuse much *fire* of the imagination into them. But while such absurdities as "controlled combustion" and the endless schemes of the boiler improver still find credulous victims, it can never be out of place to disseminate sound ideas on the great gift of Prometheus to men—fire. Every young man who has to do with the management or use of this most useful servant should familiarize himself with all its capabilities, so as to be beyond the alluring solicitations of quack boiler improvers.

NEW METHOD OF ANNULLING THE EFFECTS OF INDUCTION IN TELEPHONE CIRCUITS.*

IT is useless for me to explain what induction in a telephone circuit consists in; every one knows the cause and especially the effects of it—called in popular language telephone "frying."

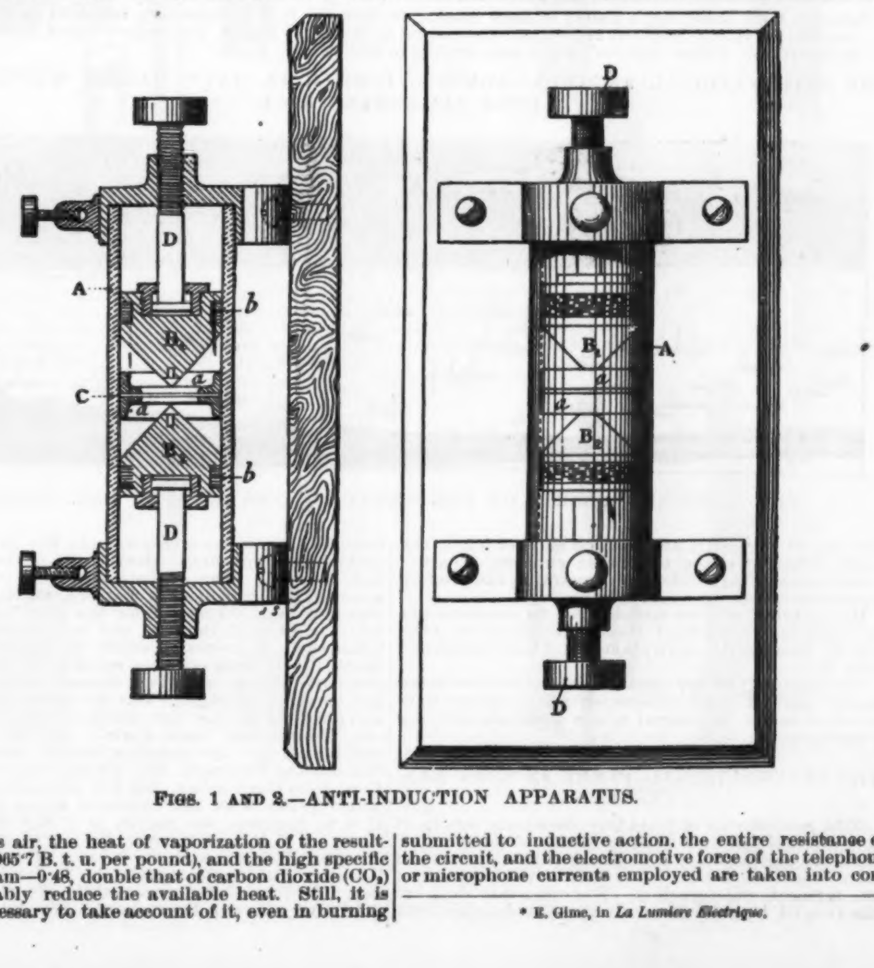
During the several years that I have been engaged in telephony, I have been seeking a palliative for the disastrous effects just mentioned, and, after many failures, have reached a very practical result.

FIG. 3.

After trying all the anti-induction systems that I know of, most of which are so complicated as to become impracticable, I assert that few have given the results that I obtain with the simple apparatus which I am about to describe.

This apparatus, which I interpose in series in the telephone circuit, is shown in Figs. 1 and 2. A is a glass cylinder divided into two parts in the center by a paper or parchment diaphragm, C, mounted in a copper ring, *a*; and B¹ B² are pistons which are hermetically adjusted in the cylinder by means of packing, *b*. The extremities of these pistons are conical and have sharp platinum tips. It will be seen that the rod, *d*, that is adjusted to these pistons permits of varying the distance of the piston points from the diaphragm, through the threaded part, which engages with the copper caps of the cylinder, that carry the terminal designed for connecting the conductor with the apparatus.

In regulating the apparatus, the length of the line submitted to inductive action, the entire resistance of the circuit, and the electromotive force of the telephone or microphone currents employed are taken into con-



FIGS. 1 AND 2.—ANTI-INDUCTION APPARATUS.

* E. Gime, in *La Lumière Electrique*.

sideration. The free space between each cone and the diaphragm is filled with a reducing gas.

By inspecting Fig. 1, it will be seen that only the undulatory currents (of a very high potential) produced by the magnetic telephone or the induction coil of the microphone transmitter will be able to pass from B^1 to B^2, while the induced currents on the same line will have too low a potential to overcome the great resistance opposed to their passage.

This apparatus can also be arranged so as to permit of a telegraphic transmission and a telegraphic communication on the same line. To effect this I place an anti-induction apparatus and a telephone apparatus in series on a circuit derived from each end of the telegraph line, and then connect the derived circuit with the earth. As may be seen, I thus have a telegraphic and a telephonic circuit upon the same line.

It will be perfectly understood that the telegraphic currents cannot traverse the derivations formed from the line to the earth, and that, on another hand, the feeble intensity of the telephonic currents, a part of which passes into the telegraph apparatus, can produce no pernicious influence on the latter.

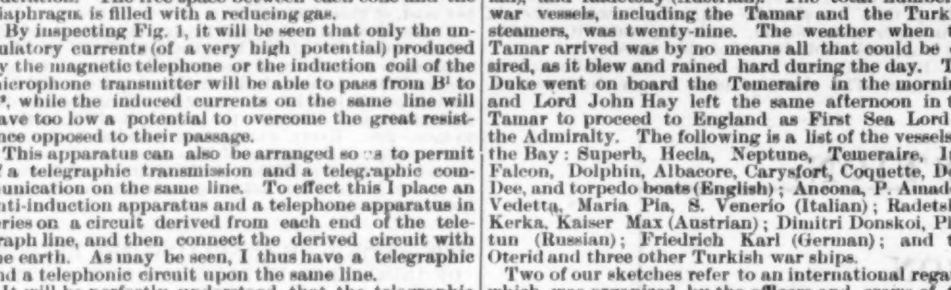
It is possible, without preparation, to communicate by telephone with a fixed station at any point of the line by forming the derivation that I have mentioned (Fig. 3).

The simplicity of my apparatus permits of its being readily used, at slight expense, on all telephone lines which it might be desired to use simultaneously for telegraphy.

THE INTERNATIONAL FLEET IN SUDA BAY, CRETE.

THE general view of Suda Bay shows the whole of the international fleet lying in the harbor on March 5, with the arrival of H.M.S. Tamar with the Duke of Edinburgh, who had come to take over the command of the international squadron. The other flag-ships are the Dimitri Donskoi (Russian), Principe Amadeo (Italian), and Radetsky (Austrian). The total number of war vessels, including the Tamar and the Turkish steamers, was twenty-nine. The weather when the Tamar arrived was by no means all that could be desired, as it blew and rained hard during the day. The Duke went on board the Temeraire in the morning, and Lord John Hay left the same afternoon in the Tamar to proceed to England as First Sea Lord of the Admiralty. The following is a list of the vessels in the Bay: Superb, Hecla, Neptune, Temeraire, Iris, Falcon, Dolphin, Albacore, Carysfort, Coquette, Don, Dee, and torpedo boats (English); Ancona, P. Amadeo, Vedetta, Maria Pia, S. Venerio (Italian); Radetsky, Kerka, Kaiser Max (Austrian); Dimitri Donskoi, Plastun (Russian); Friedrich Karl (German); and the Oterid and three other Turkish war ships.

Two of our sketches refer to an international regatta which was organized by the officers and crews of the various British, Austrian, Italian, Russian, and German vessels now assembled in Suda Bay to prevent an outbreak of hostilities between the navies of Greece and Turkey. The various admirals commanding accorded their names as patrons, an international committee was formed under the presidency of Captain Compton E. Domvile, and the programme comprised thirteen events, in which all departments were allotted their share—officers, seamen, marines, stokers, and boys. There were two courses, respectively one and two miles in length. Our sketches depict the start and finish for the last race, which was open to all comers. Twenty-two boats started, and the course was well rowed, the race finishing abreast of the English flag-ship the Temeraire. The winning boat was Admiral Lord John Hay's galley, the five succeeding boats, to which prizes were also adjudged, being the barge of H.M.S. Neptune, the launch of H.M.S. Superb, the cutter of H.M.S. Temeraire, the gig of the Principe Amadeo (Italian), and the whaler of the Maria Pia (Italian). During the regatta the Italian boats won a large number of the prizes, while the Russians and Austrians also won their share. The English boats were for the most part heavier than the others, but carried off a large proportion, about half the prizes, the Temeraire's boats securing the lion's share.—*London Graphic.*



THE INTERNATIONAL REGATTA.—THE START FOR THE OPEN ALL-COMERS' RACE.

1. Admiral Lord John Hay's galley (8 oars) coming in first. 2. H.M.S. Neptune's barge (14 oars) coming in second. 3. H.M.S. Superb's launch (20 oars) coming in third. 4. H.M.S. Téméraire's cutter (14 oars) coming in fourth. 5. Prince Amadeo's gig (8 oars) coming in fifth.

THE INTERNATIONAL REGATTA.—ADMIRAL LORD JOHN HAY'S GALLEY WINNING THE OPEN ALL-COMERS' RACE.

THE COMBINED FLEETS OF THE GREAT POWERS AT SUDA BAY, CRETE.

HOG CHOLERA.*

By W. J. SULLIVAN, M.R.C.V.S.

INFECTIOUS pneumo-enteritis, or, as it is more generally styled, swine plague or hog cholera, has been the subject for very thorough investigation by able pathologists on both sides of the Atlantic, and interests the greater portion of the people of Connecticut directly or indirectly by the sad havoc that indicates its presence among our herds of swine in different portions of the State, affecting materially our food supply, and (due to the lack of inspection of meat) rendering possible our consuming the tainted flesh of diseased animals, and introducing into our systems the germs of a very loathsome, insidious disease, exhibiting the more prominent symptoms of typhoid fever, anthrax, erysipelas, measles, and scarlatina, with which diseases the earlier investigators confounded it.

Definition: It may be defined as a specific contagious fever of swine, characterized by a high but variable temperature, by congestion, exudation, ecchymosis, and ulceration of the intestinal mucous membrane, especially that of the cæcum and colon, and to a less extent of the stomach, by congestions and exudations in the lungs in the form of lobular pneumonia, by general heat and redness of the skin, swellings of lymphatic glands, irregularity of bowels, costiveness alternating with fetid diarrhœa (the peculiar, offensive, and fetid smell of the exhalations and of the excrements may be considered as characteristic of the disease). The duration of the disease varies according to the violence of the attack and the age and constitution of the patient.

When the attack is violent and its principal seat is located in one of the vital organs, such as the heart, the disease has sometimes terminated in twenty-four hours; but when the attack is of a mild character, and the heart is not seriously affected, and the animal is strong and vigorous, one or two weeks usually intervene before death. If the termination is not fatal, convalescence requires an equal and, not unfrequently, a much longer time; a perfect recovery seldom occurs; in most cases some lasting disorder remains behind, and more or less interferes with the growth and fattening of the animal. Those that do recover give but poor return for the amount of food and trouble, and from a pecuniary point of view it ought to make little difference to the owner whether the animal recovers or not. The attack is always most violent and fatal where large herds of animals are closely confined in small and dirty inclosures, or in ill-ventilated and filthy pens.

The disease has its seat in many different organs of the body, hence the great variety of morbid changes, and its different aspects in different animals. In some cases the principal seat of the disease may be in the respiratory and circulatory organs, and in others in the digestive organs; death may therefore result from different causes in different cases. In some cases it results from cessation of the functions of the heart, the lungs, etc., and in others it is the consequence of the inability of entirely different organs to perform their allotted functions. This being the case, the post-mortem appearances would necessarily greatly vary, but in all animals similarly affected the lesions and morbid changes are found identical.

Perhaps the most important point determined by investigators was the contagious and infectious character of the disease. A series of exhaustive experiments was conducted with this end in view by the ablest pathologists in this country and in Europe. Prominent in this country were Drs. Law of Cornell University, Detemers of Illinois, Boyles of Indiana, Salmon of North Carolina, Dunlap of Iowa, Dyer of Illinois, Payne of Virginia, McNutt of Missouri, Hines of Kansas, and Lyman of Massachusetts.

These experiments resulted in determining the fact that the disease is both infectious and contagious, and that it is not alone confined to swine, but that other animals may contract it in a mild form, and retransmit it to swine in its most virulent and malignant character. To follow the various experiments, inoculations, etc., the attenuation and artificial propagation of the virus, etc., by the different investigators, would be both tiresome and profitless to the general reader, for whose perusal this paper is intended. Some of these experiments included the confinement of healthy with diseased animals, the inoculation of healthy animals with diseased products of those suffering with the fever, and the feeding of portions of the intestines, etc., of animals that had died of the plague to healthy ones, in every case with the result of successfully transmitting the disease from sick or dead animals to healthy ones.

Dr. Klein, F.R.S., of London, England, who has published a very lengthy and valuable treatise on this malady, referring to its contagious character, states: "Its contagiousness is pronounced even when no marked alteration in the animal's condition can be perceived. And it is on this account that the disease deserves great attention, for infection may have been carried out a hundredfold by animals which to the owner and buyer present all the characters of soundness. More than that, an animal, although smitten already with the disease, and sowing contagion broadcast, may change hands several times, and may thus have infected one herd after another before its condition becomes pronounced enough to be recognized by its last owner; such being the case, to trace the source of infection becomes in many instances a matter of extreme difficulty." Dr. Klein does not consider the disease very transmissible to man, and cites in support the exposure of himself and his assistants to this disease, through contact with diseased animals, living and dead, during their investigations.

The experiments of Dr. Law have shown the period of incubation to vary greatly, though in a majority of cases it terminated in from three to seven days after inoculation. Referring to experiments of others for determining the period of incubation, Dr. Sutton, observing the result of contact alone in autumn, sets the period at from thirteen to fourteen days; Professor Axe in summer in London gives the period from five to eight days. Dr. Budd in summer four to five days, and Pro-

* From the Seventh Annual Report of the Connecticut State Board of Health.

fessor Osler in autumn at from four to six days. Dr. Detemers gives the period five to fifteen days, or an average of about seven days. A comparison of these results would seem to indicate that both extremes have been reached.

The microscopic investigations of Dr. Detemers also revealed some important facts. His discovery of a new order of bacteria, or bacillus, which he names "Bacillus Suis," as it is common only to this disease of swine, and his failure to inoculate healthy animals with virus from which these germs had been removed by filtration and otherwise, would lead to the conclusion that these microphytes are the true seeds of the hog cholera.

These germs are invariably found in one form or another in all the fluids. So constantly were they observed in the blood, urine, mucus, fluid exudations, etc., and in the excrements and in all morbidly affected tissues of diseased animals, that he regards them as the true infectious principle. They would seem to undergo several changes, and to require a certain length of time for further propagation. If introduced into the animal organization, a period of incubation or colonization must elapse before the morbid symptoms make their appearance. These germs were generally found in immense numbers in the fluids, but more especially in the blood and in the exudations of the diseased animals. With the proper temperature and the presence of a sufficient amount of oxygen, they soon develop and grow lenghwise by a kind of budding process. A globular germ constantly observed under the microscope budded and grew under a temperature of 70° F. twice the original length in exactly two hours, and changed gradually to rod bacteria or bacilli. Under favorable circumstances these bacilli continued to grow in length until, when magnified 850 diameters, they appear from one to six inches long. A knee or angle is first formed where a separation is to take place, and then a complete separation is effected by a swinging motion of both ends. After the division, which requires but a minute or two after this swinging motion commences, the ends thus separated move apart in different directions.

These long bacteria seem pregnant with new germs, their external envelope disappears or is dissolved, and then the numerous bacillus germs become free, and in this way effect propagation. A change observed by Dr. Detemers, but the cause of which he was not able to determine, was observed in the fact that the globular bacteria, or bacillus germs, commence to bud or grow, when very suddenly their further development ceases, and partially developed *bacilli* and simple and budding germs congregate to colonies, agglutinate to each other, and form larger or smaller irregularly shaped and apparently viscous clusters. These clusters are frequently found in the blood and in other fluids, and invariably in the exudations of the lungs and in the lymphatic glands in pulmonal exudation, and in blood serum the formation can be observed under the microscope if the object remains unchanged for an hour or two. The clusters are believed to be instrumental in producing the extensive embolism of the lungs and other tissues.

In the water of streamlets, brooks, ditches, ponds, etc., the vitality of these germs is retained or preserved for some time. In fluids and substances subject to putrefaction they lose their vitality, and are destroyed in a comparatively brief period; at least, they disappear as soon as those fluids and substances undergo decomposition. In the blood they disappear as soon as the blood corpuscles commence to decompose or putrefy. They are also destroyed if brought in contact with or acted upon by alcohol, carbolic acid, thymol, iodine, etc.; the destruction of these germs by decomposition would seem to account for the harmless nature of thoroughly putrid products when consumed by healthy animals.

Treatment.—The remedial efforts practical may be described as entirely disinfectant, with close attention to the sanitary conditions and isolation of the infected animals. All the experts who have given this disease their attention unite in declaring the therapeutic treatment adopted by each as lacking in success, and do not encourage treatment, but the speedy slaughter of the pronouncedly affected, thus destroying the plague with its habitat and propagator. If the question of the preservation of the infected pig was the only one or the main one to be considered, I would strongly advocate medicinal treatment. But the question is rather one of comparison between this one sick hog or herd and all the healthy swine in the same town, county, State, or nation. If, then, the preservation and treatment of a single sick hog means the incessant and incalculable increase in its body and secretions of a poison which is in the last degree deadly to other hogs, if this poison can be dried and preserved for a length of time, and carried meanwhile to a distance of a thousand miles, and if not hogs alone but sheep, guinea-pigs, and even wild animals, like rabbits and mice, can contract the disease and convey the poison to any distance in their bodies, then the best interests of the nation demand that the sick animal shall not be preserved, but promptly sacrificed to the good of the community. Dr. Law states in reference to this point: "Some of my experimental pigs were successfully inoculated with quills that had been dipped into the morbid exudations of sick pigs in New Jersey and North Carolina, and had been dried and preserved for from one to six days in this condition." Here we have the thinnest possible film, such as might have adhered to the clothing of a man, the hair of an animal, the feet or bill of a bird, the legs or prehensile organs of an insect, to a dried leaf, or even to a floating thistle-down, and might have been thus carried in a great many different ways to infect distant herds. Professor Axe inoculated from ivory points on which the cutaneous exudation had been dried up for the long period of twenty-six days, and produced the disease, which tends to show the vitality of the virus and the many possible modes of transportation, facts which, when viewed collectively, will clearly indicate the rather arbitrary means of seeking safety in vigorously stamping out this dread plague; the fact that every tissue and fluid in the animal is so thoroughly permeated by the virus of this disease, even when the external manifestations are not developed sufficiently to attract the especial attention of the owner, and when the animal is most likely to be butchered and used for human food, would strongly indicate the necessity for a careful inspection of the flesh of such animals, and especially would an intelligent veterinary sanitary inspectorship be necessary during the reign of this pestilence, empowered to isolate and stamp out this scourge of the husbandman, as has been done in European countries, where an outbreak is confined by the veterinary inspectors to the farm or district where such outbreak occurs, saving thereby a large item of expense to the country, and preventing the diminution of the food supply of its inhabitants, a condition economic, and devoutly to be wished.

HOW TO GRAFT.

GRAFTING is one of the most important operations connected with practical fruit growing, and it is so easily learned and so very successful in changing trees of inferior sorts into those more valuable, that no fruit grower should fail to learn all the various ways of performing it.

The theory of the practice rests on the fact that when the cion is so placed in or on the stock that the cambium layers of the two are in contact, immediately on the

FIG. 1.

FIG. 4.

sap beginning to move they unite, and the cion at once becomes part and parcel of the tree. This union, however, is only of the growth made subsequent to the operation, and never extends to the wood existing when the grafting is done.

While most trees may, under very favorable circumstances, be successfully grafted, the apple, pear, plum, and cherry are those in which farmers are most interested. And these can be grafted with success in the order named.

Cleft Grafting, Fig. 1, is the form most commonly used, and is adapted for stocks from five-eighths of an inch in diameter to those of three inches. The stock or

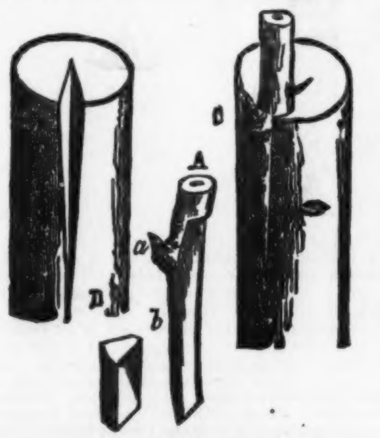


FIG. 2.

limb is sawed square off with a fine saw, and is then split, as shown, with a "grafting knife," which can be purchased for a small sum at most hardware stores. The cions are "whittled" so as to be wedge-shaped, having the wedge part longer or shorter according to the diameter, and a little thinner on the side designed to go toward the center of the stock, and are cut to such a length as to contain two or three buds. A "wedge" or the wedge part of the grafting knife is drawn into the "cleft" or split of the stock, until it is open sufficiently to receive the cions, two of which are inserted, if the stock is one inch or more in diameter. And here let us say that in all forms of grafting, care must be used in

FIG. 3.

placing the cion so that the cambium layer (that part between the bark and wood) of it and the stock shall be in direct contact. After the cions are crowded down snug, the wedge is withdrawn, and the whole "waxed." In all styles of grafting, great care must be used that the ends of the stock and cions and the whole slit be covered with wax, so that no air can gain admittance to any cut surface.

Groove Grafting, Fig. 2, is another form that may be used where the stocks are so cross-grained or tough that they will not split with a smooth edge. It is also adapted to grafting grape-vines, etc. The groove shown at D is cut with a fine saw by taking out a V-shaped piece. The cion is whittled to the shape shown at A, and a small section at *b* is made of such a size that, when driven into the groove by a few taps with a small mallet or stick, it will fit tightly when the cambium layers are in contact. If the stock is large, two or more cions may be used, putting them on different sides.

Slip Grafting, Fig. 3, is another form that may be used where the stocks cannot be smoothly split. It may also be used in connection with cleft grafting where limbs three or more inches in diameter must be cut. In this the bark is slit and slightly raised. The cion is cut half off square, the remaining portion is then cut slanting toward the bark to a point. This part is then inserted into the opening in the bark and crowded down till the square part rests upon the end of the stock. All of these features are shown in the cut, although this does not show the wedge part of the cion as large as it should be left.

FIG. 5.

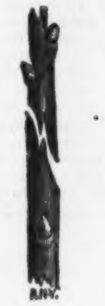


FIG. 9.

Bear's Mouth Grafting, Fig. 4, is still another form that may be used where the stocks are refractory. It has the advantage of having more of the wood of the cion left to resist high winds, which are sometimes destructive to young grafts. In this, the stock is sawed in two places nearly as wide apart as the cion is thick, and an inch and a half down the side; this piece is then nicely cut out with a chisel or a narrow-bladed knife. The small cion is slightly scerfed on the side, and cut half off with a slant that will fit into the "kerf." The remaining portion is then cut to a point with a long taper; the bark of stock is then slit below the kerf, and the point of cion is inserted and pushed down under it until the slanting portion of the cion is crowded down into the "bear's mouth."

Wired Grafting, Fig. 5, is an entirely new method

FIG. 6.

FIG. 8.

of grafting, for a cut and description of which we are indepted to our good friend J. V. H. Nott, of Kingston, N. Y. It avoids all splitting of stock or rupturing of bark, and he says it has proved with him very successful, and far ahead of the old style of cleft grafting. The cions are cut squarely off, and holes are made in the center, and a piece of No. 18 wire, 1½ inches long, is forced into each, half an inch. One or more holes are then made in the end of the stock in such position

FIG. 7.

that when the wires projecting from the cions are forced into them, the cambium layers of cion and stock are brought firmly into contact, and the parts are then well waxed.

Side Grafting, Fig. 6, is successfully used wherever it is desirable to produce a limb on the side of a young

tree, to balance the top, or for any other purpose. A cross is cut on the side of the tree, and a slit is made as if for budding. The cion, cut with a long slant, as shown in cut, is inserted and crowded firmly down, when the whole is nicely waxed. In this form, which is really a variation of budding, it is sometimes necessary, for a short time, to support the young growth by tying it up to the body or some higher limb.

The above are all forms of grafting designed for large trees and for larger limbs. Where cion and stock are of nearly the same size, some of the following methods are used.

Splice or Whip Grafting, Fig. 7, is very nicely done where both scion and stock are of the same size. Here both are cut with the same length of slants, and are then placed together so as to have the cambium layers in contact, and secured by tying with a string, and the whole is covered with wax or, more commonly, wound with waxed cloth.

Saddle Grafting, Fig. 8, is used where the stock is from the size of the cions to two or three times as large. The upper end of the stock is whittled to a wedge, the cion is split, and each side cut to a point. It is then crowded firmly down upon the wedge, and secured by tying and waxing, or with waxed cloth.

Tongue Grafting, Fig. 9, is mostly used by nurserymen for root grafts. It may also be advantageously used in grafting the small limbs produced where, for any cause, grafts set in large limbs have failed.

In this method a long, even slant is made on both stock and cion. The knife is then reversed, a cut is made parellel with the grain; these are then caused to interlock with each other, and crowded well together and tied and waxed, or bound with waxed cloth. The figure shows the tongues raised as they would be after the parts had been crowded together and have remained so for some time.

Split Grafting, Fig. 10, is also used by nurserymen where stocks only a little larger than the cions are to

FIG. 10. FIG. 11.

be used. In it the stock is split, and the cion, whittled wedge-shape, is inserted and crowded down firmly, and the whole wound with waxed cloth, or bound with string and covered with wax.

Crown Grafting, Fig. 11, is a little the best style of grafting where we wish to do an extra nice job, and have the wound heal over in the least time and make the least scar. In this the stock is cut with a slant, the bark is slit and raised at both the apex, behind, and base of the slant, in front. The cion is split in the middle and a distance equal to the slant on the stock added to the distance it is desired to have it extend under the bark below the slant; one half is merely cut wedge-shape at the point; the other is cut off an inch and a half long, and is whittled, from the inside, to a point. It is then applied to the stock as shown in the cut, the shorter end being inserted beneath the bark at the apex, and the longer end at the base-slit, and both are pressed home till the cion sets closely and firmly to the stock, when it is bound with the cloth, or tied with string and waxed.

Of course, in all these forms of grafting in which the cion or any part of it is to be inserted and slipped down beneath the bark, the operation must be deferred until the bark becomes more or less loose; the other methods may be practiced at any time from the opening of spring till the trees are in bloom; for apples, pears, plums, and cherries must be grafted very early or not at all, as after there has been the least circulation of sap, grafting is almost sure to fail. Split grafting and tongue grafting, when used in grafting apples or pears for nursery purposes, may be done at any time during winter, and if the "grafts" are packed in damp sand, after being "worked," and kept in a moderately cool cellar, they will be found nicely united by planting time, and, if well cared for, scarcely one in a hundred will fail to grow.

Grafting Wax can be made according to various formulas. Four pounds of resin, two pounds of tallow, and one of beeswax make a very good wax. Six pounds of resin, one pint of raw linseed oil and two pounds of beeswax also make a good article. Four pounds of resin, two pounds of beeswax, and one and one-half pounds of tallow make a capital though rather expensive wax. In all cases the materials are to be melted together, thoroughly stirred, and poured into cold water and pulled by hand until nearly white. To prevent the wax from sticking to the hands, the latter must be kept thoroughly wet and be occasionally greased with tallow.

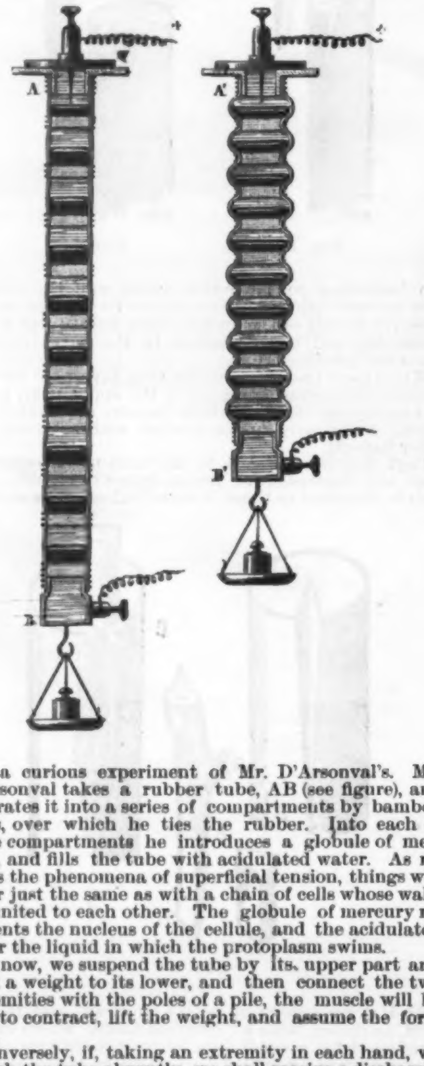
Waxed Cloth is made of any old calico or muslin, or may be made of rather tender new muslin saturated with a mixture of four parts of resin, two parts of tallow, and two parts of beeswax, melted together. To saturate the cloth, it is torn into strips about ten inches wide, and closely wound upon a small iron rod into a roll of any convenient size. These rolls are kept immersed in the hot mixture until fully saturated. The cloth is then drained of all surplus mixture, and unrolled and laid upon any wet surface to cool. In using, it is torn into strips a half inch wide, and these are wound upon the grafts, the bands overlapping each other so as to be air and water tight.—*Rural New-Yorker.*

CHANGES OF FORM IN, AND MOTIONS OF THE ANIMAL CELL.

THE changes of form in the animal cell and the motions thereof are due to its plasticity and to the phenomena of superficial tension. Like the protoplasm that it contains, the cell possesses irritability, that is to say, it is capable of undergoing a modification in form, or of moving after any external chemical or physical excitation.

But, while protoplasm can only transform the external energy that is communicated to it by excitation, the cell is capable of furnishing at its own expense the energy necessary for its motions; so that excitation does not play the part of motive power, but simply that of a setter free.

In order to show in what this difference consists, and to what this new property of the cell is due, we shall



cite a curious experiment of Mr. D'Arsonval's. Mr. D'Arsonval takes a rubber tube, AB (see figure), and separates it into a series of compartments by bamboo disks, over which he ties the rubber. Into each of these compartments he introduces a globule of mercury, and fills the tube with acidulated water. As regards the phenomena of superficial tension, things will occur just the same as with a chain of cells whose walls are united to each other. The globule of mercury represents the nucleus of the cellule, and the acidulated water the liquid in which the protoplasm swims.

If, now, we suspend the tube by its upper part and hook a weight to its lower, and then connect the two extremities with the poles of a pile, the muscle will be seen to contract, lift the weight, and assume the form A'B'.

Conversely, if, taking an extremity in each hand, we stretch the tube abruptly, we shall receive a discharge.

Kuhne has performed a like experiment with an artificial cell made by filling a hydrophilus' gut with protoplasm.

But in these two experiments, which so well show the role of the phenomena of superficial tension in the phenomena of cellular contraction, it is we who furnish the necessary energy by means of an electric current or by a mechanical action. With the cell, on the contrary, things go on as if the D'Arsonval tube were placed in an oxidizing liquid capable of attacking the mercury and traversing the rubber wall through endosmosis, and as if we were free to suspend the reaction at will.

In order to render the analogy complete, it would be necessary to have the reaction brought about by a body such as platinum sponge. Every time this latter was brought near it, the mercury would be attacked, the nature of the surfaces of contact would be altered, the superficial tension would vary, and we should observe a change of form in the globule. This action would be suspended as soon as the sponge was removed, and, owing to the products of the reaction being rapidly carried to the exterior by diffusion, the surfaces of contact would return to their first state. The globule would then assume its pristine form, and the contraction would cease.

This is the way in which things go on in the cell. It bathes in a liquid containing free or combined oxygen, and which, in the higher animals, is blood containing oxygen combined with a special substance—hemoglobine. Any excitation whatever—a purely mechanical action, the action of an acid, electric action, or any other—will have the effect of hastening the decomposition of its protoplasm into non-nitrogenized matters and soluble ferments.

But these latter act immediately, through their presence, upon the inner nucleus, and bring about a combustion of these substances at the expense of the oxygen of the surrounding medium.

We therefore have an attraction of the surfaces of contact occasioned by chemical action and variation in superficial tension, and consequently a distortion of the cellule.

If the external excitation chances to cease, the ferments will be carried along or serve to renovate the protoplasm. The products of the reaction, also, will be eliminated through diffusion, and the cell will regain its pristine form.

But we see that the energy necessary for the motions of the cellule is due to the oxidation of a portion of the substance of the nucleus. Hence: (1) Every external excitation acts upon the cellule so as to cause the production of ferments capable of destroying the substance of its nucleus, and that too in destroying the conditions of equilibrium necessary for the existence of its protoplasm.

(2) The mechanical cause that determines the distortion of the cell and its motions is due to the phenomena of superficial tension; but the necessary energy is formed by the oxidation of the substance of the nucleus brought about by the presence of ferments.—*M. Leblanc, in La Lumiere Electrique.*

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